# HURRICANE HUGO: LEARNING FROM SOUTH CAROLINA

by

H. Crane Miller
Washington, D.C.



A Report to the
Office of Ocean and Coastal Resources Management
National Ocean Service
National Oceanic and Atmospheric Administration
U.S. Department of Commerce

October 1990

# National Oceanic and Atmospheric Administration
# Weather Bureau Hurricane Series

# TABLE OF CONTENTS

## TABLE OF CONTENTS
## (continued)

# HURRICANE HUGO – LEARNING FROM SOUTH CAROLINA

H. Crane Miller
Washington, D.C.

## EXECUTIVE SUMMARY

**Background.**
During the last two decades, the coast of South Carolina underwent explosive development, driven by a tourist economy that produces 35% of the state's income. This development helped make tourism the state's second largest industry after textiles. Coastal development in South Carolina took place in a largely laissez faire regulatory context. Adoption of state-approved construction codes was optional for each community; enforcement was often minimal, for there was no state or other mechanism to ensure enforcement once codes were adopted. Marginal design and building practices combined with little or no code enforcement to produce high concentrations of understrength buildings along the coast. Not until the last two to five years can one find consistent enforcement by building officials of coastal construction regulations of the National Flood Insurance Program (NFIP), and, to a lesser extent, to the Standard construction codes adopted by localities.

**Code Enforcement.**
Elsewhere there was a strong correlation among good code enforcement, new construction that complied with NFIP regulations for elevation, and reduced flood damages. Residences built before NFIP regulations were enforced locally suffered the greatest flood damages--slab on grade foundations, unreinforced concrete block walls, and spread footing/concrete block pier foundations had high rates of failure.

As shown on the coast of South Carolina and elsewhere in the United States, good code enforcement can make a significant difference in reducing damages and allowing families and communities to resume their normal lives soon after a disaster. But code enforcement alone is not sufficient, nor does it work in a vacuum. It is part of a total system in which the market component of owners, builders, suppliers, lenders and insurers have a greater responsibility than building officials for the success or failure of buildings in natural disasters. Where it succeeds, the market components perceive and assume their responsibilities for the quality of construction and for buildings' ability to resist dynamic wind, water and seismic forces; the building official encourages, educates, cajoles, insists, and applies the minimum code standards firmly and fairly. Good code enforcement has a relatively small part in the total construction process, yet can make a significant difference in the losses incurred in a disaster.

**Flood Damages.**
Properly sized wooden or reinforced concrete pilings adequately embedded in the ground to resist uplift and overturning loads, uniformly performed well in reducing flood damages.

Enclosed areas, utilities, HVAC units and anything else installed beneath elevated buildings and subjected to rising or wind driven water were uniformly destroyed or heavily damaged.

**Wind Damages.**
Both old and new construction incurred strikingly high levels of wind damage. Evidence is strong that wind speeds did not exceed the design fastest-mile wind speeds of the codes adopted by communities on the South Carolina coast. While 135 mph winds reported by the National Hurricane Center were recorded by NOAA aircraft at about 10,000 feet, anemometer records from seven sites showed consistently lower velocities (around 100 mph and lower) at ground level and when adjusted to standardized wind speed at 33 feet above the surface. In light of the wind speeds recorded on land in the Charleston area and the barely hurricane strength winds experienced in the Grand Strand/Myrtle Beach area, the wind damages were high, a bitter result of widespread underdesign and marginal building practices.

Fully 80% of the roofs of Charleston were damaged by Hugo's winds; roofs opened by the winds generally could not be patched or covered to protect interiors from heavy rains that fell two days after the hurricane passed. All along the coast aged roofing materials, poor roof maintenance, poor roof covering installation practices (number and size of fasteners, failures caused by high wind suction at eaves, hip joints, and roof peaks), failure to use or the use of inadequately sized hurricane clips, and failure to tie houses together adequately from the roof to the walls, the walls to the floor and foundation, and thence into the ground, were commonly observed.

**Roofing Materials.**
Even where builders complied with building code requirements, roofing materials frequently failed to withstand the forces experienced. Standing seam sheet metal roofs, slate, asphalt shingles, roofs of hotels and commercial establishments -- all roofing types experienced a range of minor to catastrophic failures. Review of wind insurance adjusters' files strongly indicated that once a roof was opened, high interior damages from rain occurred.

**High-rise Buildings.**
Tall buildings (hotels, condominiums, office buildings) generally performed well structurally along the South Carolina coast. However, extensive damages to cladding, secondary framing, and sliding exterior glass doors were found. They are of particular concern in areas such as the Grand Strand where wind speeds were well below design wind velocities. Although a building may be engineered by a structural engineer, the architect is typically responsible for the cladding, windows, doors and other openings.

**Commercial Buildings.**
Small commercial buildings, motels and other buildings of unreinforced or lightly reinforced concrete block typically fared poorly in both flood and wind damages. Wind often damaged

or destroyed doors, windows and poorly attached roofs: concrete block walls subjected to wave action and swiftly moving water frequently broke from impact forces or from being undermined by scour.

**Manufactured Buildings.**
Manufactured buildings may represent one-half of the residential structures now being purchased in South Carolina. They are particularly susceptible to flooding and wind damages, underdesigned for high wind velocity zones such as South Carolina's coast. HUD standards require that manufactured homes located in the hurricane zone be designed to resist horizontal wind loads of 25 psf and net uplift loads of 15 psf -- equivalent to about 95 mph winds if sheltered, but 80 mph if located in open beach areas.

South Carolina is one of several states without standards for installation of manufactured housing. However, NFIP regulations require all participating communities to elevate and anchor manufactured buildings in flood hazard areas. Widespread failure to enforce those regulations at the local level resulted in overturned houses that toppled off unattached, uncemented concrete blocks, anchors that pulled out of wet soil, and inadequate hold down straps.

## RECOMMENDATIONS

Conditions found on the South Carolina coast after Hurricane Hugo can be found elsewhere on our coasts. With the conditions found in South Carolina particularly in mind, the author recommends the following:

**Governmental Actions.**

- **Studies of private sector incentives.** NOAA/NOS/OCRM should undertake studies of incentives and disincentives to encourage the lending and insurance industries to participate more actively than now in improved building practices for coastal development.

- **Wind speed data.** The National Weather Service, private meteorological service companies, and military and naval bases should operate and maintain a geographically widespread network of recording anemometers or other wind speed measuring devices to provide reliable long-term wind speed data.

- **Remapping.** FEMA should give high priority after disasters such as Hugo to the remapping of V and coastal A Zones and complete the remapping as swiftly as possible (preferably before major rebuilding and new construction take place), taking into account:

- Storm erosion that results in long-term alteration of the beach profile;

- Small, low volume dunes which were eroded or overtopped during the storm and which provided little or no protection from wave action and flooding;

- Those portions of low coastal barriers that were totally inundated at depths that would support a three-foot wave, and extending the V Zone landward accordingly.

- **Wind and saturated soil conditions.** FEMA should revise its regulations to take high wind velocity and saturated soil conditions into account when approving foundations for elevating site-built and manufactured homes.

- **Mitigation benefit in flood insurance policies.** FEMA should explore the means and costs to provide a mitigation benefit in flood insurance policies to be applied exclusively against the additional costs of rebuilding in order to comply with flood hazard mitigation regulations.

- **Flood insurance claims files review.** FEMA/FIA should review its adjusters' files in detail to determine the extent claims may have been made or paid, or both, for decks, utilities, equipment, materials and other contents installed or stored beneath the first elevated floor level of houses and other insured buildings.

- **Spread footing foundations.** FEMA should withdraw its approval of spread footing/concrete block pier foundations on the coastal barrier islands of the United States, and in other flood prone areas subject to high velocity winds.

- **HUD Manufactured Building Standards.** The U.S. Department of Housing and Urban Development should strengthen its standards for manufactured homes to address:

  - performance requirements for ground anchors in various soils under saturated conditions;

  - negative wind pressures;

  - design criteria for wind loading in Zone II, the Hurricane Resistive Zone, taking into account the added velocity pressure that may be exerted when homes are elevated to or above the 100-year flood level;

  - establishing a new Hurricane Resistive Zone III for areas which may experience fastest-mile wind speeds greater than 110 mph in a 1% chance (100-year) storm, and assign correlating design values for manufactured homes sold or destined for such areas.

- **Manufactured home installation standards.** The State of South Carolina should prepare and adopt regulations governing the installation of manufactured homes in high wind, flood prone areas, including anchoring, tie-downs, foundations, elevations, and site location, with particular regard for wind and seismic resistance where buildings are elevated to avoid flood hazards. As a minimum, NFIP standards for installation of manufactured homes should be enforced at the local level.

Private Sector Actions.

- **Insurers' roles in mitigation.** State insurance offices, in conjunction with property insurers in the state, should study incentives, disincentives, and revised insurer practices to prevent or mitigate wind, flood, earthquake and related damages through improved building practices, including (1) rates that reflect the quality of construction and construction materials, (2) insurance-related inspections for loss reduction in new construction, existing construction, or both, and (3) insurer cooperation with local governments to encourage, educate, lobby, or provide financial or other incentives for effective code enforcement.

- **Education.** The Southern Building Code Congress International (SBCCI), professional building associations, design professionals, and other groups involved with construction in hurricane prone coastal areas should increase their continuing education activities in proper coastal building practices for building officials, architects, engineers, builders, carpenters, and others.

- **Education programs for local government.** SBCCI, the South Carolina Building Codes Council, and other code groups should work with professional associations to extend education programs on community development and code enforcement to the executive, legislative and judicial branches of local government.

- **"Heavying up" high wind construction standards.** SBCCI and other code groups should review their construction standards for high wind areas with a view to "heavying up" their standards for fasteners, framing (especially around openings), sheathing, and roofing materials.

- **Roofing material wind testing.** The American Society for Testing and Materials (ASTM) should revise its test procedures for "wind resistant shingles" to provide test data on: shingles weathered in coastal environments; and shingles' ability to resist winds greater than 60 mph and to resist suction pressures over eaves, gable ends, hip joints, roof peaks, and other vulnerable locations.

# HURRICANE HUGO – LEARNING FROM SOUTH CAROLINA

H. Crane Miller
Washington, D.C. 20016

## I. Introduction

During the last two decades, the coast of South Carolina underwent explosive development driven by a tourist economy that produces 35% of the state's income. This development helped make tourism the state's second largest industry after textiles. Coastal development in South Carolina took place in a largely laissez faire regulatory context; adoption of state-approved construction codes was optional for each community. Code enforcement was minimal, and no state or other mechanism ensured enforcement once codes were adopted. Not until the last two to five years can one find consistent enforcement by building officials of coastal construction regulations of the National Flood Insurance Program (NFIP), and, to a lesser extent, to the Standard construction codes adopted by localities.

Concerned with increasing development near its beaches and dunes, with rising sea levels, increasing rates of erosion, and with the threat that eroded beaches could reduce tourism to the state's coastal areas, in 1988 the state enacted its Beachfront Management Act, amending the Coastal Management Act of 1977. The Beachfront Management Act established coastal construction setback programs, while adopting policies of retreating from the beach/dune systems over a 40-year period, promoting sand renourishment to preserve beaches, and eliminating seawalls and other "hard" erosion control devices. Litigation challenging the constitutionality of the South Carolina Coastal Council's setback provisions quickly followed publication of its guidelines, but Hurricane Hugo was the first major test of the Council's guidelines across the board.

In its severity Hurricane Hugo revealed a wide spectrum of building and management practices ranging from excellent to execrable. In high wind, high surge areas, the best performing residential buildings exceeded building code requirements at the insistence of the owners. These buildings suffered relatively little flooding and wind damage, permitting owners and their families to return to their homes after little personal disruption.

No such distinction could be made regarding wind damages -- both old and new construction sustained wind damages ranging from minor to catastrophic over a wide geographical area. From Kiawah Island to North Myrtle Beach along the coast, and hundreds of miles inland, damages resulted from poor roof covering installation practices, poor roof maintenance, aged roofing materials, failure to use (or use of inadequately sized) hurricane clips, and general failure to connect building components together adequately to resist the wind pressures experienced. Of particular concern were the extensive damages caused in certain areas where sustained wind speeds barely reached hurricane velocities, well below the design wind velocities called for in the applicable building codes.

Code enforcement ranged from very good to nonexistent in coastal communities. Where code enforcement was good within the past five years, building practices tended to be better than where the opposite was true, and damages appeared to be reduced. Every current building official was burdened with a large existing building stock that failed to meet building codes and failed to meet the minimum requirements of the NFIP. The damages and destruction sustained as a result of poor building practices and little or no code enforcement were a bitter harvest of a long legacy of real estate development free of regulatory intervention. Much of the damage was preventable.

Evidence is strong that where the private sector and the market work closely and cooperatively with state and local governments, both private economic and public policy, health, safety and welfare goals are enhanced. In a social and political context that demands low government involvement, much more could be done by the building, lending and insurance industries if people want to reduce the damages and costs of natural disasters such as Hurricane Hugo. As was demonstrated by the South Carolina Coastal Council and by building officials whose code enforcement was both firm and fair, government regulatory intervention in the market can increase the survivability, profitability, and continuity of businesses while satisfying public policy goals for enhancing the environment and the public well being.

This report describes a variety of problems and conditions observed in South Carolina resulting from Hurricane Hugo. Included in the consideration are a damage survey with implications for building practices (including manufactured structures), regulatory measures, and the insurance industry.

## II. Building Practices for Coastal Construction

A wide range of building age, setbacks, elevation, building practices, maintenance, and other important factors were found in South Carolina:

- Several houses built in the early 1800s can be found on Sullivans Island; much construction took place immediately after World War I; and a high percentage of the coastal building stock had been built before NFIP regulations were published and enforced.

- On parts of the Isle of Palms and Sullivans Island, accretion on the oceanfront increased the effective setbacks of buildings and substantially reduced wave and surge damages that might otherwise have been incurred. There was a distinct, observable relationship between depth of setback and level of damages; the greater the setback the fewer the damages.

- Elevations of houses bordering the Atlantic ranged from ground level to 22 feet above mean sea level. Those below the NFIP 100-year flood levels tended to incur extensive damages, if not total destruction. Slab on grade construction and unreinforced masonry (bricks and concrete blocks) foundations (piers) or structural walls were particularly vulnerable.

- Buildings varied considerably from houses built to be expendable if a storm struck, to manufactured buildings, to very expensive structures built on site. While less costly buildings tended to be vulnerable to flood and wind damages, costliness was no guarantee that building practices used were appropriate to the dynamics of the coastal environment. Many very expensive structures suffered extensive interior damages when their roofs, windows or walls failed.

The sections that follow contain summaries of observations made by the author and other members of the National Research Council's Committee on Natural Disasters, including coastal engineer Hsiang Wang of the University of Florida, Billy Manning of the Southern Building Code Congress International, and Peter R. Sparks of Clemson University. This part of the report concludes with a description of the building practices of one builder whose residential buildings resisted flooding and wind damages unusually well. Appendix A describes conditions and damages observed in communities from Folly Beach to North Myrtle Beach.

## A. Foundations.

Three basic types of foundations were seen in common use along with South Carolina coast: slab on grade and poured footings; masonry piers; and wooden and reinforced concrete pilings.

- Slab on grade and poured footings. Along the entire coast where properties were subject to waves or storm surge, slab on grade and poured footing foundations repeatedly proved unfit for coastal construction. Slab on grade foundations were invariably found in older structures built before enforcement of NFIP regulations.

- Piers. Use of concrete block piers on shallow, noncontinuous footings is an unusually widespread building practice in South Carolina. They frequently failed in flood zones where FEMA's guidelines deemed them permissible. Their performance indicates that they are unfit for all flood insurance V Zones and many coastal A Zones for a number of reasons:

  - Shallow footings, often no deeper than two feet below the surface. While the footings may adequately distribute the dead load (gravity) weight of the building, the footings often fail when subjected to uplift and overturning forces of hurricane-strength winds and storm surge.

-- Vulnerability to scour around the footing, further decreasing the building's resistance to uplift and overturning forces. Where soils become water saturated and the foundations are subjected to scour, wave, moving water, and other dynamic water forces, masonry/concrete pier systems consistently perform poorly.

-- Inadequate reinforcement bars; concrete block piers frequently failed because builders placed an inadequate number of (often undersized) reinforcing bars, creating weak points by not splicing the reinforcing bars together adequately; failed to fill the blocks properly with concrete; or had weak joints between the pier and the footing, within the pier, between blocks, or between the top of the pier and the building.

-- Seismic vulnerability; in areas such as South Carolina, unreinforced or lightly reinforced masonry piers provide little resistance to ground shaking and are subject to collapse. This is of considerable concern for site-built and manufactured buildings which are being elevated on masonry piers after the storm in response to FEMA requirements for mitigating flood hazards.

**Pilings.** Both wooden and reinforced concrete pilings, when adequately sized and properly installed, performed very well during the storm. Round wood pilings tended to perform better than square pilings; they are often stronger and available in greater lengths than square pilings. Some problems were observed with rot on older wood piling foundations, insufficient piling penetration in the ground, and inadequate piling size for the building being supported.

Lateral cross bracing proved desirable, especially steel rod bracing well bolted into the pilings. Wood bracing often performed well if bolted into the pilings and if not subjected to heavy impacts by waves and debris. Wood bracing that was nailed into the pilings provided significantly less bracing resistance than when bolted, and was more vulnerable to weakening by corrosion than were galvanized bolts.

Concrete pilings (both prefabricated and poured in place) can be very effective foundations for coastal construction. If properly sized and embedded deeply enough, they provide good rigidity and excellent resistance to uplift and overturning forces. They also require quite simple connections to floor beams. Failure due to brittleness, weakening from exposure to salt water, voids in poured concrete, and corrosion of reinforcing bars are among the potential negative features of concrete pilings.

B. Roofs.

From Kiawah Island to North Myrtle Beach, residences and commercial buildings, both engineered and nonengineered buildings, incurred extensive roof damage. Fully 80% of the roofs of the City of Charleston were damaged. Many houses in pine forested areas were opened to rain and wind by trees falling on the houses, or were pierced as the upper parts of pine trees snapped and fell. In contrast to the distinct difference in the extent of flood damages between newer elevated and older unelevated buildings, wind damages to roofs did not discriminate by age--no basic change has taken place in roofing practices to resist wind damages as has occurred under NFIP regulations to elevate structures above coastal storm surge and waves.

By far the greatest number of roof failures seen were related to roofing materials, fasteners, and maintenance.

- **Roofing Materials.**

  -- **Standing Seam Sheet Metal.** Found on a high percentage of the residential, commercial, and governmental buildings in the City of Charleston, and elsewhere along the coast, these roofs frequently failed at the roof edge as wind swept under the sheet metal and peeled it back. The building official on Sullivans Island reported one instance of this type roof failing in the middle of the roof, not at the edge. Some parts of Charleston were impassable immediately after the storm because of the quantity of sheet metal and other debris on the streets. Particular attention is needed in fastening the sheet metal at the roof edge, and in protecting wood at the roof edge from rot, or in periodically replacing the wood if rot occurs. Standing seams must be properly crimped to provide a tight seal against water and to help hold the roof together when subjected to direct wind and suction pressures.

  -- **Asphalt shingles.** There is widespread use of asphalt shingles on residences on the coastal barrier islands. Frequent failures were seen on windward roof edges, roof hip joints, roof peaks, and some mid-roof areas. Closer inspection showed that roofers often failed to use the number of nails recommended for fastening the shingles in high wind areas.

  These practices are fostered in part by the way roofing installers are paid. Installers are generally paid by the bundle -- the greater the speed and the greater the number of bundles installed, the greater the pay. Using a greater number of nails per shingle slows the installer's output and reduces his pay, unless some other method of compensation is expressly agreed upon to assure proper installation.

  Professor Sparks of Clemson University and others suggest that even if the shingles were installed and fastened properly, large-scale failure would probably have resulted. Under current industry testing standards, to be designated a "wind resistant shingle," a shingle must be able to resist a 60 mph wind directly over the surface of the shingle. The tests used do not deal with the suction over gable ends, hip joints and roof peaks, precisely where many of the failures began. Nor do they deal with weathering in the coastal environment.

- **Fasteners.** Roofs frequently blew off for lack of proper connection of the roof components to the exterior walls. Rafters may have been connected to the top plate simply by nailing, without the use of hurricane clips; often when undersized hurricane clips were installed they were inadequate to resist lateral and suction pressures. Other common failures included undersized nails and inadequate nailing schedules for sheathing to the rafters and shingles to the sheathing.

- **Maintenance.** Some of the roofing failures observed in Charleston and on the coastal barriers related to maintenance. Especially on older buildings, where roof leaks had permitted wood to rot, or where fasteners were weakened or broken by corrosion, the roof system was vulnerable to being opened by the winds. Although Hugo was a relatively dry storm, heavy rains caused extensive water damage two days after the storm. Owners and officials of the areas repeatedly spoke of the impossibility of finding sufficient plywood or tarpaulins immediately after the storm to provide temporary cover for roofs opened by Hugo's winds. One owner told the author of $50,000 of water damage caused to the interior of his house two days after the storm; he had been unable to find anything to cover his roof in time to prevent the rain from penetrating. On Sullivans Island, one new home which incurred $180,000 of damage to its roof, interior, and contents, may have incurred much of the interior water damage in the deluge two days after Hugo passed.

### C. Openings.

Contemporary coastal buildings typically have large window areas facing the ocean which are particularly vulnerable to failure from wind pressure and flying debris. The author found not one single instance of permanently installed hurricane shutters or other permanent window/opening protection in the communities visited. Moreover, a relatively small percentage of homes used plywood or other window covers to protect against the storm. One result was a high incidence of window breakage and interior damages caused by wind-driven rain.

Sliding glass doors and large window areas are particularly susceptible to failure at their frames. Reinforcing the frames and door slides with bracing screwed into the floor and frame can provide additional strength and stiffening, taking some of the lateral wind strain off the fasteners holding the window and door frames.

D. High-Rise Buildings.

High-rise hotels, condominiums and office buildings generally performed well structurally along the South Carolina coast. These are fully engineered buildings, capable of structurally resisting the wind and water forces to which they were subjected. However, these same buildings often sustained extensive damages to cladding, secondary framing, sliding exterior glass doors, and to enclosed ground level areas.

- Cladding. Probably responding to owners' demands for lighter, less costly buildings, one frequent result observed was the underdesign of buildings' cladding. Cladding failures were found especially at building corners and, where buildings were set close together (as in Myrtle Beach) on walls subjected to high wind velocities between the buildings. Analysis of the negative pressure of wind vortices at corners indicate that some of the cladding materials used may be understrength by a factor of four in some high wind areas. [Peter R. Sparks, personal communication].

  One example was found in high-rise condominiums at the north end of the Isle of Palms. Located on the beach with a fully uninterrupted view of the ocean, the buildings used a metal stud system and were clad with ½-inch gypsum board glued to a light-weight, 1-inch-thick Styrofoam, 1/8-inch fiberglass/stucco system. The cladding failed at building corners where the system was subjected to direct high lateral pressures and suction pressures as winds passed. Similar failures were found on high-rise buildings in the Garden City area. Once opened to the storm, insulation, framing, interior drywall, floors, carpets and furnishings were often damaged or destroyed and widespread wind and water damages were inflicted on the interior of the building.

  According to Professor Sparks one of the reasons for these failures may lie in the divided responsibility for building design. The structural engineer is generally responsible for the frame, the structure of the building. They are generally not responsible for the cladding, windows, and roof coverings of buildings -- these are usually the responsibility of the architect. If not experienced with design for coastal construction, the potential is high for misreading the wind tables of the building code and manufacturers' specifications for cladding.

- **Openings -- Sliding Glass Doors.** As noted earlier regarding single family residences, sliding glass doors and other openings frequently failed. The doors consist of large surface areas supported only at their edges, often by lightweight aluminum frames that bend and yield before the wind. In some condominiums a few owners opted for hurricane shutters/covers for their apartments' windows and doors. These apartments generally performed well, but may have been affected when their neighbors' unprotected apartments failed. Thus, one result was uneven performance of the building. Several examples were seen where unprotected doors and windows broke and interior walls collapsed, rendering interior halls impassable and displacing anyone living there, whether their apartment's doors and windows were protected or not. To the best of the author's knowledge, no condominium association mandated that all owners have storm shutters or covers, but instead made such protection optional.

- **Ground Level Enclosures.** While some of the most recently built multi-story structures kept the ground level of the building open for parking, a far greater number of high rises along the Grand Strand enclosed those areas. Those that did generally lost everything on the ground level to surge and wave action. In many instances the enclosed areas were designed to break away in a major storm, and did, apparently without causing any structural damage that has been reported publicly. What disruption of business or other use of the building was caused by the loss of those areas could not be determined. However, it is certain that the pressure to allow those areas to be enclosed again will be great. The rarity of major storms and the economics of use of the space obviously dictate for some owners that the space be used for income-producing purposes, even if they are unable to obtain insurance coverage. In some instances, however, damages could not be repaired swiftly and the establishments were still not back in business five months after the storm.

**E. Manufactured Buildings.**

Historically, the number of manufactured homes and the severity of damage to those homes have been disproportionately high when compared to site-built homes exposed to the same disasters. This is significant in South Carolina, where the National Conference of States on Building Codes and Standards (NCSBCS) estimates that about half of the single family homes are manufactured homes.

Under a contract with the Department of Housing & Urban Development, NCSBCS investigated the causes of failures sustained by manufactured homes following Hurricane Hugo. [1] The NCSBCS investigations were to determine both the cause of failures and which structural components of manufactured homes were most apt to fail. A NCSBCS engineer inspected three manufactured home parks in the Charleston area which contained about 125 homes. The damage experienced is consistent with the damage to manufactured homes observed in other parts of the state. The primary damage reported was:

- **Tie-down/anchors.** About 70% of the homes had shifted from their piers; half of those were completely off their supports. Reasons for the shifting were:

    -- Anchor failure after heavy rains saturated the ground and greatly reduced anchors' resistance. Many anchors were totally pulled out of the ground or had sliced through the soil and were bent;

    -- Strap Failure. In some instances tie down straps had broken when subject to excessive wind pressures.

- Anchor straps improperly attached to I-beams. Strap clips on many homes were clipped to the bottom flange of the I-beams as opposed to being wrapped around the beams as required by installation instructions. When clipped to the bottom flange, minor rocking of the home allowed the clips to fall off the I-beams.

- Ground anchors were installed at wrong angles. The angle at which ground anchors are installed should generally be similar to, or in line with, that of the tie-down straps.

- **Metal Roofs.** About 15% of the homes lost between 20% and 100% of their metal roof covering. Several had minor roof truss damage. Homes with shingled roofs tended to fare better than metal roofs. Typically individual sections of roofing were completely torn from the homes exposing the units to extensive rain and wind damage. In all cases, when the roof covering was torn from the home, the staples fastening the roof to the edge rail were also torn out of the edge rail.

- **Siding.** About 15% of the homes had siding or soffit damage. Most damage was concentrated at the end of units; damage was limited to homes with metal and vinyl siding. The primary reasons for loss of siding was the leeward suction forces at edges and ends of homes.

- **Demolition.** About 8% of the homes were totally destroyed. Where homes overturned, the anchor and strap failed. Other homes were destroyed by wind pressures that separated the entire roof from the home, causing walls to fall when the roof trusses no longer provided support.

Preliminary conclusions and recommendations by NCSBCS included:

- **Tie-Down/Anchoring.** Shifting off piers or overturning were generally caused by ground anchor failure from saturated soils or improper installation of anchoring devices. NCSBCS stated that since approved installation instructions are provided with all manufactured homes, proper set up and securing can be enforced by state or local jurisdictions. Twenty-one states, including South Carolina, have not adopted any tie-down regulations, contributing to a widespread problem of improper installation of manufactured homes. The problem is particularly severe in high-wind, flood-prone coastal areas.

- **Anchor Failure.** Water saturated soil provides little resistance to uplift forces and anchors are easily pulled out of the ground. HUD standards require anchoring equipment to resist an allowable working load of 4,725 pounds. Most installation instructions provided by anchor manufacturers, however, do not adequately address the performance of ground anchors in various types of soil, particularly when the soil is saturated.

- **Negative Wind Pressure.** The most common damage observed after Hurricane Hugo was the loss of siding at the ends of manufactured homes. Manufactured homes are designed to standards to resist only inward wind pressure on the windward side of manufactured units. When air flows over and around an object, it exerts both inward and outward (suction) pressures. Suction is also called negative pressure. Negative pressure is not addressed by the HUD standards.

- **Metal Roofs.** Metal roof connections to the side walls or trusses were the most frequent failure points. In general, stiffening, bracing, and tightening the metal roof would have helped to reduce the extensive damage experienced. In turn. roof connections should undergo dynamic analysis as well as static load analysis to account for vibration and flutter.

- **Re-evaluate the Design Criteria for Wind Loading of Structures in Hurricane Zone II.** HUD standards designate two wind zones: a Standard Zone (Zone I); and a Hurricane Zone (Zone II). Standards require that homes located in Zone II be designed to resist horizontal wind loads of 25 psf and net uplift loads of 15 psf. These design criteria do not apply to wind conditions over 95 mph; in areas where homes are not afforded wind protection by hills, trees, etc., such as open beach areas, the design criteria would not apply over 80 mph, the low end of a Category I hurricane.

NCSBCS recommended that HUD establish a hurricane Zone III for areas which experience winds of 125 mph or greater, and assign correlating design values for manufactured homes located in those areas. Criteria would be derived from ASCE 7-88 (ANSI A58.1).

The NCSBCS investigation dealt primarily with wind induced damages, and did not address flooding damages experienced by manufactured homes on the South Carolina coast. Extensive destruction and damage to manufactured homes caused by coastal surges occurred from Charleston County to North Myrtle Beach. Residents in the Copahee subdivision north of Charleston (opposite Dewees Island) experienced up to 15.5 feet of surge through their community, destroying or heavily damaging all manufactured buildings in the subdivision.

In this respect they performed no worse than homes built on site which were not elevated. No such structures are designed to withstand the hydrostatic, hydrodynamic, and impact forces to which they were subjected. Properly elevating the home above potential flood levels is the only practical way to eliminate anticipated forces associated with surge.

On rebuilding in the Copahee subdivision, manufactured homes are being elevated ten feet and more above the ground, above the 100-year flood level, most frequently on spread footing/concrete block piers with no cross bracing or anchoring to resist uplift and overturning forces, and with no evidence of consideration being taken of the effects of saturated soils on the stability of the foundations or the structures. The homes are subject to higher wind velocity pressures than if they were at ground level, but no strengthening of the manufactured homes or their foundations to resist those additional pressures is evident -- by elevating they could potentially fail at lower wind speeds.

Moreover, the Copahee structures and their foundations are extremely vulnerable to any seismic shaking that might occur. The height, light reinforcement of the piers, and the use of spread footings with very shallow soil penetration may make the owners and the structures more vulnerable to seismic and wind hazards than before the storm.

**F. Building for the Coastal Environment.**

While much remains to be learned within the building community about effective coastal construction, the author saw several examples of excellent practice -- indeed, some of the best seen anywhere on the coasts of the United States. In each case the owners chose to build beyond the minimum requirements of the building code, paying a premium of about 7% of the capital cost in labor and additional costs for stronger materials and fasteners in order to "heavy up".

In each case observed, the building suffered no structural damages, and only minor damages to cladding or to roof shingles. In the instance described below, the house was built in a V Zone on an accreting portion of a coastal barrier. Principal damages were scour of some of the soil beneath the house, breaking of the concrete slab where the soil was scoured out, breakage of some of the lattice skirt around the perimeter of the house, and loss of a few shingles at the hip joints of the roof. Had the owner chosen to build farther landward, he might well have avoided even these minor losses.

The home of builder Ken Hancuff of Isle of Palms is located in a V9 flood zone requiring elevation 18 feet above mean sea level to avoid the surge and waves of a 100-year (1% chance) storm. Setting out to design for a Category V storm, Mr. Hancuff elevated his house to 22 feet above mean sea level, using 30-foot-long round pilings sunk up to 20 feet in the ground. The extra 4 feet of elevation entitled him to the lowest flood insurance rates available, rates that would swiftly pay for the extra cost of the pilings through reduced premiums as against what he would have had to pay if he elevated only to the 100-year flood level, or lower. "The key is to build as high as you can . . . You can build to 160- to 170-mile-per hour winds, but you can't build to one-mph water movement."

His home is notable for a number of details from the peak of roof to the foundation, and include:

- Heavier-than-required bolts and double the recommended number of hurricane clips through the house;

- 2 x 6 studs and 3/4" plywood sheathing on the seaward face of the house to provide rigidity lost from window and door openings; extra wood bracing around the inside of double-paned window frames to increase windows' resistance to lateral wind pressures;

- 1/2" plywood sheathing elsewhere on the walls; all sheathing fastened with 16d hot-dipped galvanized common nails;

- 5/8" plywood on the roof, fastened with 16d nails, 12" nailing schedule, 6" nailing at the seams; 30-lb. felt paper over the plywood, versus 15-lb. felt commonly used, added watertightness integrity;

- Gable ends with no greater than 12" overhang and 6", 16d nail schedule; shingle overhangs of 1/2", with adhesive caulking on the underside of shingles at the roof edge;

- At the roof hip joints, 8" copper flashing over the mitred shingles with 8" nail schedule and shingle caps nailed over the flashing; 2" roofing tacks to anchor well in the roof sheathing;

- Plywood nailed to the top of attic rafters to provide an additional seal against water entering the house if the roof failed, to take some of the internal pressure off the roof if a window or door broke on the floors below, and to provide extra stiffness against racking (twisting) by wind;

- 1" steel rod cross-bracing between exterior pilings, each rod bolted to the pilings and each rod covered with PVC pipe and sealed at the ends with a liquid plastic tool grip dip to reduce corrosion of the rods;

- Breakaway lattice walls/curtains around the base of the house, and expendable concrete slab beneath the house;

Damages to the property from Hugo were relatively minor including: loss of some cap shingles at the hip joints of the roof; scour beneath about a quarter of the house which caused a 10-15 foot section of the concrete slab to break, but with no visible damage to the foundation or to the house; loss of some sections of the breakaway lattice; and destruction of a boardwalk. Windows on the second and third floors were boarded before the storm; there was insufficient time and plywood to cover windows on the first floor -- no windows or other openings were broken. The roof did not leak. The only evidence of any racking of the building were two 1½-inch-long cracks in the corners of a kitchen door frame.

Mr. Hancuff estimates that the measures he took added about 7% to the capital cost of his home. These extra costs included: about $1.00/sq. ft. (about 30%) for framing labor (about $4,000); $5-$6/sheet extra for 3/4" plywood on the seaward side of the house and in the attic (about $500-$600); $300-$400 for hurricane clips, heavy bolts, and other fasteners (including stainless steel screws to fasten porch railings and resist corrosion).

There is a certain intangible price of anxiety for living in one of the most exposed sites on the Isle of Palms, vulnerable to potential erosion, wind and water hazards. Nevertheless, having chosen to live there his attention to wind and water forces and to all aspects of his home's construction led to his home succeeding well when put to the test. One important result of the extra care taken by Mr. Hancuff was that he and his family returned to their normal lifestyle within days of the storm. Many others still had not many months after the storm.

## III. Regulatory Measures

The principal regulatory measures in force in South Carolina to reduce storm damages are construction codes, code enforcement, the regulations of the National Flood Insurance Program, and the South Carolina Coastal Council's Beachfront Management Act. Each is discussed in this part.

### A. Construction Codes.

The first known building codes adopted and used in South Carolina were developed for Charleston in 1907, followed by the City of Columbia in 1916. Thereafter, certain cities and counties individually developed construction codes. By the mid-1960s a variety of construction codes were in force with little consistency in interpretation and construction practices; a movement to standardize construction codes statewide grew during that period.

In 1987 the state approved the Southern Standard Building Code (now the Standard Building Code) as the state-approved code. South Carolina's construction code legislation has both mandatory and voluntary features as enacted. Adoption of a construction code is optional to each individual jurisdiction. However, if a construction code is adopted it must be the current edition of the Standard codes, the National Electric Code, or the One and Two Family Dwelling Code of the Council of American Building Officials (CABO). Currently the codes approved by the State Building Codes Council include: the 1988 Standard Building Code; 1988 Standard Mechanical Code; 1988 Standard Plumbing Code; 1987 National Electric Code; 1988 Standard Fire Prevention Code; and 1986 CABO One and Two Family Dwelling Code. Local amendments to any adopted code cannot be made without approval of the South Carolina Building Codes Council.

Codes have been adopted in all of the <u>coastal</u> counties, cities, and towns of the state, but only one-third of all of the state's counties have done so. (See Appendix B, which lists and depicts the building code adoption status of counties in South Carolina). Moreover, there is no state mechanism to ensure that codes are enforced once adopted, nor to ensure the qualifications of building inspectors. Aided by the experience of Hurricane Hugo, bills introduced in the state General Assembly to require a mandatory state building code and to provide for the training and certification of building inspectors were considered in the 1990 session. For a synopsis of the proposed legislation, see Appendix C.

The bills encountered considerable opposition, and their fortunes waxed and waned in active legislative maneuvering. Reported out of committees in both the House and Senate, both were stalled on the contested calendar of their respective houses late in the session. The session closed without a vote on the bills. Although construction codes may not have been adopted by a given local jurisdiction, all cities, towns and counties are subject to specific statewide mandated state or federal building standards. Residential projects up to three stories high or 16 units are subject to the CABO One and Two Family Dwelling Code and also subject to the Standard Building, Mechanical and Gas Codes, and to the National Electric Code. All commercial and residential buildings, other than single and two-family residences, are subject to the first eleven chapters of the Standard Building Code and the National Electric Code. Finally, any building built in a flood zone in a community participating in the National Flood Insurance Program is subject to the elevation and other performance standards of that program.

Vulnerability to Natural Hazards.
South Carolina has a particular need to integrate its construction codes because of its vulnerability to earthquake, wind, and flooding hazards. Table 1 estimates the recurrence intervals for earthquakes in the state and region.

**Table 1**

**Approximate Recurrence Intervals for Earthquakes Within the Southeastern United States**

| Modified Mercalli Scale | Approximate Richter Magnitude | Approximate Recurrence Intervals: South Carolina | Approximate Recurrence Intervals: Southeastern Region |
|---|---|---|---|
| VI | 5 | 10 years | 3 years |
| VIII | 6 | 100 years | 20 years |
| X | 7 | Unknown | Unknown |

Source: Earthquake Hazards, Risks, and Mitigation in South Carolina and the Southeastern United States, The South Carolina Seismic Safety Consortium, The Citadel, Charleston, S.C. (1987).

A recently completed three-year evaluation of earthquake vulnerability of the Berkeley-Charleston-Dorchester tri-county area underscored that "there is as great a potential for earthquakes to kill, injure, and damage in Charleston and South Carolina as there is in Southern California and parts of other western states." [2] Public school buildings in the region were singled out as being particularly vulnerable because of the widespread use of unreinforced masonry construction.

The widespread use of lightly reinforced spread footing concrete block piers for site-built and for manufactured buildings is also vulnerable to seismic activity, particularly when the buildings are elevated for flood insurance purposes. Earthquake provisions have been adopted in the Standard Building Code only in the last two years. No evidence was found that those provisions are being considered or used in the new construction or post-storm reconstruction viewed in the state.

Wind. [3]
The entire state of South Carolina is subject to tornadoes and other severe windstorms, and as Hurricane Hugo amply demonstrated, large areas of the state can be devastated by hurricane strength winds. Wind speed maps (ANSI A58.1-1972) adopted by the Standard Building Code and the HUD Manufactured Home Construction and Safety Standards include most of South Carolina in zones subject to hurricane strength winds with a 2% chance of recurring annually (50-year mean recurrence interval). The entire state potentially is subject to hurricane strength winds in the 100-year (1% chance) storm.

Along the coast the reach from Charleston to North Myrtle Beach is potentially subject to 90 mph fastest-mile wind speeds in the 50-year (2% chance) storm; 110-120 mph in the 100-year (1% chance) storm. The frequency and estimated magnitude of hurricanes since 1800 and before Hurricane Hugo, as prepared by the U.S. Army Corps of Engineers, are shown in Appendix D.

Wind speeds used for design purposes are usually taken to be those which have a probability of 0.02 of being exceeded in any given year, the so-called 50-year storm. It is approximately equivalent to a Category 3 hurricane on the South Carolina coast. The design wind speed varies with the type of terrain and height above ground at which wind speed is measured, as well as the time over which measurements are averaged. An internationally agreed upon standard requires that all wind speeds be adjusted to be equivalent to measurements made at 33 feet (10 meters) in open country.

Whereas statistical records in most parts of the world are kept as peak gust wind speeds (generally average over 2-3 seconds), the measure used in most construction codes in the United States is the "fastest-mile" wind speed. The "fastest mile" measurement originated with wind recording equipment that measured the time taken for a "mile" of wind to pass the equipment. In a typical hurricane the average "fastest mile" wind speed might range from 48 seconds (75 mph) to 30 seconds (120 mph).

One current problem with the "fastest mile" concept is that the wind recording equipment to make the measurements is generally not in use at airports and sites where meteorological observations are made. The measurement must be calculated from gust wind speed or from mean hourly wind speed. Gust wind speed is typically 25% higher than fastest-mile wind speed; mean hourly wind speed is about 25% lower. When considering whether a hurricane's winds were above or below the code design wind speed, it is important to know which measure is being used (gust, fastest-mile, mean hourly), and to know the elevation at which the wind was measured.

For warning and safety purposes, the National Weather Service needs to impress those living in vulnerable areas of the approaching, imminent danger, and to motivate them to evacuate. For those reasons wind speeds used by the National Weather Service as a hurricane approaches land do not reflect building design wind speeds. Measured by doppler radar, or by aircraft penetrating the storm at high altitudes, or by other means, the wind speeds reported are higher than the design wind speeds that would result after correcting for elevation, terrain, surface friction, and other factors.

But after the storm passes, planners, leaders called upon to improve construction codes, materials manufacturers, architects and engineers, builders, and many others need to have wind speed information corrected to the internationally agreed upon standard for design wind speed at 33 feet in open country. Performance standards, prescriptive building measures, materials testing, design professionals' calculations, and a myriad of other measures require reliable design wind speed data. The National Weather Service, private meteorological service companies, military and naval bases, and others could be important contributors to the development of such data, but generally are not.

**B. Code Enforcement.**

Code enforcement observed on the South Carolina coast ranged from nonexistent to very good. Where good enforcement combined with good building practices, significantly reduced damages to structures and disruption of families' lives resulted. The opposite was also true. Consistently, buildings located near the shore that were not elevated and did not comply with coastal flooding and wind standards suffered the greatest damages.

In economic terms code enforcement is an intervention in the free market in response to community needs for health and safety. Ordinary market forces historically have proven inadequate to provide acceptable levels of fire, flood, wind and other protection for our housing and building stock. Codes grew directly out of that market failure. They are imposed through the police power and are not self-enforcing. They are coercive, a social judgment of minimum standards that should apply. They are involuntary in the economic sense that they impose additional costs on the market that the market would not voluntarily adopt absent the law.

Effective code enforcement depends on all three branches of government -- executive, legislative, and judicial. From the outset the local building official needs the support of the administrators (county executive, town manager and mayor), and the political backing of the county, city or town council. Too often code enforcement is viewed as unwarranted government interference with an individual's right to use property as he or she sees fit. What often is not seen is the relationship between good code enforcement and: (1) the increased integrity of property and its ability to survive storms such as Hugo; (2) the increased value of property and, therefore, the tax base of the community; and (3) the increased quality of property and the community's attractiveness for recreation, tourism and other economic goals.

The need for backing and understanding community goals of code enforcement extend to the judiciary. If the building official is continually thwarted by the local judge or magistrate in attempts to enforce the building code, word quickly spreads in the building community and the building official's work is neutralized. The opposite is also true. If the court backs the building official appropriately, the building official's ability to obtain code compliance is greatly enhanced.

No single formula exists for organizing and administering a successful code enforcement system, but certain traits are consistently shared by successful systems throughout the United States.

- First, they are active--active in their compliance programs, initiating compliance actions through complaints or regular inspection programs; active in using legal techniques creatively to gain compliance; active in providing technical assistance and financial assistance where available; and active in educating the public and constituency groups to support their efforts.

- Second, key individuals and groups through the legislative, executive and judicial branches understand and agree on the purpose and nature of code enforcement, the roles to be played respectively by the building official, the government's attorney, and the court, the levels of activity in each professional area, and the authority each area has to act.

- Third, code officials and inspectors are well trained and often certified for the work that they perform; officials and inspectors are encouraged or required to maintain their proficiency by regular (at least annual) continuing education programs.

Despite the experience of Hurricane Hugo, the author found code enforcement ranging from the virtually nonexistent to the very diligent. Despite great strides that have been made within the last five years, considerable ambivalence exists in South Carolina toward construction codes and code enforcement. There is great inconsistency among communities. Some have very good programs, burdened principally by being understaffed to handle both the volume of inspections required and the distances to be covered. Charleston County, for instance, is over 100 miles in length and even without the added burdens of Hurricane Hugo was experiencing high growth. Installation of a new electronic system for assigning inspections and reporting their results, expected in June 1990, should help that county in its code enforcement.

Elsewhere the author found competent, diligent building inspectors who worked firmly and fairly with local builders and owners, insisting on compliance. At least two were credited by local builders as having made a difference in the extent of damage experienced in the community. And in four instances shown to the author, owners had written to building officials after the storm to thank them for their work, stating, in effect, that only after their houses survived the storm when neighbors' houses collapsed did they understand why the building officials had insisted on compliance. In some communities competent building officials were hamstrung politically by their legislative council and the executive branch. Such political crippling was compounded in at least one instance by the local court which was openly hostile to code enforcement. Finally, the author concluded that in two communities he visited the building officials were not well qualified, trained, or motivated for their work--the evidence was found in buildings damaged by the storm which they had inspected and approved, and in rebuilding going on after the storm using noncomplying techniques that had failed during the storm.

As shown on the coast of South Carolina and elsewhere in the United States, good code enforcement can make a significant difference in reducing damages and permitting families and communities to resume their normal lives soon after a disaster. But code enforcement alone is not sufficient, nor does it work in a vacuum. It is part of a total system in which the market component of owners, builders, materialmen, lenders, and insurers have a greater responsibility than building officials for the success or failure of buildings in natural disasters. Where it is successful, the market component perceives and assumes its responsibility; the building official encourages, educates, cajoles, insists, and applies the codes firmly and fairly. Ultimately the building official has a small part in the total process, but can make a significant difference in the losses incurred in a disaster.

**C. Beachfront Management Act.**

Enacted effective July 1, 1988, the Beachfront Management Act [4] amended the Coastal Management Act of 1977 and expanded the jurisdiction of the South Carolina Coastal Council (SCCC) to regulate land immediately adjacent to the Atlantic Ocean. Since Hugo, the General Assembly has amended the Act; the following discussion reviews the original Act and its effect on post-Hugo reconstruction. A summary of the 1990 amendments follows.

The SCCC's original regulatory jurisdiction, or "critical area" extended landward only to the trough of the primary oceanfront dune or to the face of an erosion control device or to the highest uprush of waves. The SCCC had no authority to regulate development landward of those lines, and from 1977 to 1988 considerable development took place immediately behind critical area lines. The Blue Ribbon Committee appointed to study the problem of beachfront development and beach erosion found such development threatening to beach and dune resources, jeopardizing development placed too close to the damaging effects of waves during storms, and reducing the amount of dry beach that was a major attraction for tourism.

In implementing the Blue Ribbon Committee's recommendations, the Beachfront Management Act declares that development has taken place too close to the fragile beach/dune system, that erosion control devices adversely affect the system, and stated that it is the policy of South Carolina to retreat from the beach/dune system by discouraging new construction near the beaches and encouraging long-range beach management plans to include gradual retreat over a forty-year period. The Act has three basic sections: Sec. 48-39-280, a coastal construction setback program and methodology; Sec. 48-39-290, governing reconstruction of existing structures; and Sec. 48-39-300, governing new construction and statutory exemptions.

The setback is measured from a baseline which is either an ideal dune line or the most landward point of the shore in the past 40 years. The setback area is an area that is 40 times the annual average erosion rate. In addition, the Act provided for a 20 foot no-construction zone immediately landward of the baseline; nothing could be built or rebuilt in the no-construction zone unless exempted. Under Sec. 300 no new habitable structure, recreational amenity, or erosion control structure could be built seaward of the 20-foot no-construction line.

Hurricane Hugo put the South Carolina Coastal Council and its recently published coastal construction setback guidelines to the test. Under pressure to allow owners to build back swiftly, the Council's interpretation of its "destroyed beyond repair" regulations, and its regulation of "recreational amenities" (swimming pools, decks, gazebos, etc.) and erosion control devices (seawalls, revetments, etc.) were tested in a crucible of political heat and intense redevelopment pressure.

**Destroyed Beyond Repair.**

Immediately after the storm Council staff and engineering firms surveyed the coast of the state to identify as swiftly as possible those structures deemed "destroyed beyond repair", defined as "destruction . . . such . . . that more than two-thirds (66 2/3%) of the building components making up the structure must be replaced for the structure to be habitable, functional, and sound." [5]

Starting in the Myrtle Beach area, the Council quickly discerned differences made in evaluating the extent to which building components were damaged. After staff and engineers met to resolve differences, some measure of greater uniformity was achieved in terms of field evaluation. Subsequent review by the Council's Permitting Committee sometimes resulted in quite liberal interpretations of "destroyed beyond repair". If a foundation and septic system were relatively intact, permission to rebuild could be granted, subject to the Council's size and siting strictures. Under the Council's regulations, each building component was rated as a percentage of the total structure and evaluated separately. For partially damaged components estimates were made evaluating what percentage of the component remained functional. Components requiring only minor repairs were rated as totally functional.

Percentage shares of building components used in evaluating structures were:

| Building Components | Percentage of Total Structure |
|---|---|
| Foundation or pilings | 25% |
| Exterior and interior load bearing walls and beams | 25% |
| Roof system -- joists (rafters, decking and coverings) | 15% |
| Flooring | 5% |
| Doors and windows | 5% |
| Decks, porches or stairs | 5% |
| Electrical, plumbing, heating and air systems | 10% |
| Septic tank, drain fields or sewer lines | 10% |
| **Total** | 100% |

Source: South Carolina Coastal Council Interim Administrative Interpretation No. 16 (1989).

Based on the observation that no engineered high-rise buildings collapsed during Hurricane Hugo, the structural criteria in determining "destroyed beyond repair" tended to apply to one and two family residences and to low-rise commercial buildings. Questions have been raised by some involved with the process about the efficacy of the structural criteria versus market value criteria for determining degrees of destruction. Although some difficulties were experienced in administering the criteria in the wake of Hugo, the results appear to have been quite workable, and probably avoided many of the problems encountered when interpreting market value criteria.

Recreational Amenities.

As storm surge of Hugo inundated the beachfront of communities it caused extensive damages to private seawalls and revetments installed to inhibit erosion and to protect decks, swimming pools, and other recreational amenities built seaward of many hotels and condominiums. As the seawalls were overtopped or broken, the waters scoured behind the walls, undercutting decks and pools as supporting soils were eroded away. More often than not the seawalls, pools and other amenities were located seaward of the coastal construction setback line, frequently on public land reserved by the locality when the land was platted.

The issue was drawn between hotel owners and condominium associations asserting their need for the pools and amenities as an important economic part of their operation, and stated public policy to reject new erosion control devices over a 40-year period in favor of retreat from the advancing sea, beach renourishment, or both. Under "extreme" pressure to allow pools to be rebuilt, the key to the Council's position was the condition of the seawall visible to the eye. If the seawall was intact or destroyed less than 50% percent, the Council granted permits to rebuild.

**Prohibitions on Vertical Erosion Control Devices.**
Replacement erosion control devices were to have slopes no steeper than 45 degrees, were to be moved as far landward as possible, and generally the most seaward point of the replacement devices was not to extend farther seaward than the original vertical erosion control device or the landward crest of the original sloping revetment. If issued, the permit would have required the owner to renourish the beach annually at least 1.5 times the volume of sand lost to erosion, unless the permitted structure is landward of an on-going federal, state or local renourishment project.

**Beach Renourishment.**
In establishing the Beachfront Management Act, the South Carolina General Assembly found that, among other things, the state's beach/dune system was the basis for tourism that generates about two-thirds of the state's tourism revenue, and declared state policy to "promote carefully planned nourishment as a means of beach preservation and restoration where economically feasible." The economic underpinnings of the policy can be found in property values, tourism revenues, and tax receipts from the state's coastal counties.

In 1986, tourists spent $3.9 billion in the state, 58% of which ($2.3 billion) was spent in five coastal counties: Horry (52.5%); Charleston (24.2%); Beaufort (18.7%); Georgetown (3.1%); and Colleton (2.1%).

In 1988 the Corps of Engineers estimated that the value of front row coastal development for the 37-mile reach from North Myrtle Beach through northern Georgetown County approached $1.5 billion, including nearly $1.2 billion in structural value and $280 million in land value. [6] See Appendix E. The Corps further estimated that the average annual equivalent damage potential to the 1,400 structures in that area was $20.55 million.

Coastal counties payments comprised over 61.2% ($125.7 million) of the tax receipts and 64.8% ($15.2 million) of the local tax receipts generated by tourism in 1986. The coastal counties also shared their 2% accommodation tax receipts from hotel and motel rooms with other counties throughout the state, Horry County alone accounting for 40% of the $11 million statewide accommodation tax collections. The values of the area and the contributions they make to the state's economy appear well documented by the Corps' and other studies. [7] Based on its studies, the Corps estimated that beach nourishment along the Grand Strand could have a 4.5:1 benefit:cost ratio, to provide protection from a 5-year surge level event.

What actions will be taken regarding beach nourishment on the coast of South Carolina, and who will pay for them, had not been established when this report was written.

**Litigation.**
Before the storm the Council had found about 1,247 structures on the coast affected to some degree by the 20-foot no-construction zone landward of the setback baseline. In 75% of the cases the owner's lot was large enough to permit rebuilding of a 1,000 square foot home or

business landward of the no-construction zone, and in 65% of the cases a 2,000 square foot structure. Of the affected structures, 306 (25%) were on lots that were not large enough to accommodate a 1,000 square foot building. [8]

Following the storm the Council denied about 150 permits to rebuild under its "destroyed beyond repair" criteria, leading to a spate of more than 50 court cases challenging the regulations. These were over and above a number of cases currently on appeal where owners of undeveloped lots had claimed that the setback provisions and the Council's denial of permits to build had effected a taking without just compensation, violating the Fifth and Fourteenth Amendments of the Constitution of the United States. Other potential litigation awaits court decisions on the pending cases.

In the first round of litigation trial courts held in a two instances that the plaintiffs had suffered no adverse consequences from enforcement of the Act, and denied relief. In two other cases where the Council denied permits to owners whose undeveloped lots lay totally seaward of the baseline the courts held that the Council's action constituted a taking. The courts further ordered that the owners be compensated for their lots and title be passed to the State. Appeals of these cases were pending when this paper was written.

**1990 Beachfront Management Act Amendments.**

After intense debate over the future of beach management in South Carolina--one set of amendments would have deleted all reference to a retreat policy and removed the BMA's strictures on erosion control devices--the General Assembly passed amendments to the BMA in June 1990. The most significant changes include:

- **Elimination of the Dead Zone.** The General Assembly eliminated the dead zone immediately landward of the baseline, thus allowing limited construction on many lots that were unbuildable under the 1988 law.

- **Erosion Control Devices.** The prohibitions against erosion control structures were strengthened by prohibiting the construction of all erosion control devices, not just vertical structures, and by clarifying definitions of seawall and bulkhead damage. However, the requirement that all vertical devices be removed within 30 years was dropped, and a gradual approach to removing erosion control devices destroyed beyond repair adopted. Until 1995, seawalls more than 80% destroyed above grade must be removed and may not be rebuilt. From 1995 to 2005, seawalls more than two-thirds destroyed above grade must be removed, and after 2005, seawalls more than 50% destroyed above grade must be removed.

- **Special Permits.** In an effort to avoid future takings cases, the General Assembly provided the SCCC with the discretion to issue a special permit when the location of the baseline and its restriction on development seaward of the line would render a lot unbuildable. The owners of structures allowed under such a special exemption, however, must remove the structure if it becomes situated on the active beach through erosion processes; the SCCC may impose other restrictions consistent with the goals of the BMA. In no case, however, may a structure be built on the active beach or primary dune, nor may erosion control structures be built or rebuilt under special exemption permits. The SCCC currently is drafting regulations that would allow only for a very narrow application of special permit authority.

- **Non-Habitable Structures Seaward of the Baseline.** Walkways, small decks (less than 144 square feet), public fishing piers, dune walkovers, and the like now may be constructed seaward of the baseline subject to SCCC permit review and approval.

## IV. INSURANCE

The principal forms of residential property insurance in force in South Carolina were homeowners, flood and wind insurance. As many owners found to their dismay after the storm, homeowners insurance does not provide flood or wind damage coverage. Limited by the lack of detail available in flood insurance data, the author was not able to gather statewide claims data and make detailed observations about the program. The files of the South Carolina Windstorm and Hail Underwriting Association were opened to the author and proved to be a treasure of detailed damage and financial information. While the 5,800 policies in force of the Association probably represent only a small portion of the total amount of wind insurance in force in the state, the 3,700 claims for damages to dwellings, manufactured homes, and commercial structures nevertheless are a significant sample of the total.

### A. Flood Insurance.

When Hugo struck, about $4.98 billion in flood insurance was in force in South Carolina spread over nearly 44,800 policies. As of the end of June 1990, both the Federal Insurance Administration direct flood insurance program and the Write Your Own companies [property and casualty insurance companies in the voluntary market] had closed 96% (15,157) of nearly 15,739 claims. Claims payments for both programs totalled nearly $319.5 million, for an average payment of $21,077 per paid claim. Statewide coverage and claims data are shown in Table 2.

Damage patterns observed on the South Carolina coast were similar in a number of ways to those in Galveston after Hurricane Alicia in 1983. Where buildings were built to meet or exceed the requirements of the NFIP, they suffered minimal flood damage. Such buildings tended to be found in communities where construction code enforcement was diligent. They also tended to have been built in the last 5 years. As in Galveston, however, there was an unusually high amount of wind related damage to buildings of all kinds, engineered and non-engineered. Building practices regarding wind resistance generally have not kept pace with the advances made in reducing flood damages.

TABLE 2

SOUTH CAROLINA FLOOD INSURANCE COVERAGE AND CLAIMS PAYMENTS
FOR HURRICANE HUGO (SEPT. 1989 - JUNE 30, 1990)

| | Direct | WYO | Total |
|---|---|---|---|
| Policies in Force | 2,947 | 45,457 | 48,404 |
| Coverage | $295,720,000 | $5,774,368,000 | $6,070,088,000 |
| Avg. Policy Size | $100,346 | $127,029 | $125,405 |
| | | | |
| Total Claims Made | 1,129 | 14,610 | 15,739 |
| Total Claims Closed | 1,129 | 14,028 | 15,157 |
| Dollar Amount Paid | $30,788,223 | $288,673,082 | $319,461,305 |
| Avg. Claim Paid | $27,270 | $20,578 | $21,077 |

Source: National Flood Insurance Program, data as of June 30, 1990.

Credit must be given the National Flood Insurance Program for a combination of regulatory and financial intervention in the market that has helped to reduce flooding damages. After 20 years there is strong evidence to demonstrate that the regulations and standards promulgated and promoted by the Program are becoming accepted and used by builders, enforced by building officials, accepted by local governments, and in some instances demanded by owners. Had the same volume of construction occurred without the elevation and other damage mitigation measures required by the NFIP, hundreds of millions of dollars of additional flooding damages would have been incurred on the South Carolina coast. A number of areas of concern rising from the NFIP should be mentioned, including:

- Mapping. In several communities the landward reach of wave and surge action was greater than that mapped. Small dunes had virtually no retarding effect on waves and were swiftly eroded. Upon remapping, FEMA could substantially improve its mapping accuracy by concentrating on the inland V Zone boundary and realistic wave heights in an expanded V Zone. [9]

- **Foundations.** Related to the mapping, FEMA permits use of reinforced concrete block piers in coastal A Zones where waves and water velocity are presumably not a problem. Many failures of these foundation systems occurred during the storm, notably in Surfside. Flood waters from the coastal surge softened soils on which footings rested, water moving at velocity scoured and undermined many footings, and because of inadequate soil penetration and bracing, structures frequently were unable to resist the uplift and overturning forces to which they were subjected. The author recommends withdrawal of FEMA approval of such foundation systems on the coastal barriers of the United States, and in mainland areas exposed to high winds and coastal flooding.

- **Costs of mitigation.** Costs to mitigate future flood damages are problematical for at least two categories of properties: pre-NFIP houses and manufactured homes that were knocked off their foundations but suffered damages less than 50% of their market value; and any structure that incurred damages greater than 50% of their market value.

  In the first category there is no incentive for the owner to comply with NFIP regulations for elevation. Any flood insurance payment will cover only replacement costs to the pre-storm condition of the house; extra costs to elevate the house to or above the 100-year flood level would not be covered under the standard policy. In the great majority of cases observed, owners will not incur the added costs voluntarily, and will repair and rebuild their structures, often using the same construction and construction practices that failed during the storm. These structures can be expected to be damaged and flooded again.

  In the second category if the house or manufactured home is repairable, it must be elevated to comply with NFIP regulations. In South Carolina, the cost to lift and move a 1,000 square foot home was about $9,000 to $10,000. The cost of a new piling foundation may cost another $5,000 to $10,000. In some instances, those additional costs may be beyond the means of the owner, and were so in many cases reported to the author.

  As a strategy and incentive to encourage sound mitigation practices, a flood insurance benefit with a fixed maximum amount firmly conditioned upon use of insurance proceeds for mitigation purposes could be a major contribution toward reducing repetitive losses and making mitigation affordable, while producing an actuarially sound way to shift the cost to those at risk.

**B. Windstorm and Hail Insurance.**

In an overt effort to encourage coastal development, the South Carolina state legislature created the South Carolina Windstorm and Hail Underwriting Association to make windstorm and hail insurance available on eligible properties located in the coastal area of the state. Membership in the Association is required of all private insurers authorized to write and engage in writing property insurance within the state as a condition of each insurer's authority to transact insurance business in the state. [10] Members of the Association participate in its writings, expenses, profits, and losses in the proportion that each member's direct premium written in the state during the preceding calendar year bears to the aggregate net direct premiums written in the state by all members of the Association. [11]

The Association is considered an insurer of last resort, making windstorm and hail insurance available when private insurers decline coverage voluntarily. However, as an incentive, member companies receive annual credit for windstorm and hail insurance on eligible property voluntarily written in the coastal area, and their participation in the underwritings of the Association are reduced accordingly. [12]

The "coastal area" of the state is defined by statute as:

- **Beaufort County and Colleton County.** All areas east of the west bank of the intracoastal waterway;

- **Charleston County.** Edingsville Beach, Kiawah Island, Botany Bay Island, Folly Island, Seabrook Island, Morris Island, and all areas north of the city of Charleston which are east of the west bank of the intracoastal waterway;

- **Georgetown County.** Cedar Island, DeBordieu Beach, Litchfield Beach, South Island, Pawley's Island, Retreat Beach, North Island, Magnolia Beach, and Garden City;

- **Horry County.** All areas east of a line paralleling and lying one hundred fifty feet east of U.S. Highway 17 (Kings Highway). [13]

To be eligible for insurance, properties built after September 15, 1971 must be built "in substantial compliance with the Standard Building Code, including the Design-Wind requirements therein", and "any construction and zoning requirements . . . pursuant to the . . . National Flood Insurance Program." [14]

Maximum limits at any one location are: $500,000 for one-to-four family dwellings and $1,500,000 for all other classes of property. Premiums are payable to the Association on a net basis (gross premium less the producer's commission of 10%).

Applications for windstorm and hail insurance are made on Association forms, and include front and rear angle photographs of the building indicating the condition of the roof [15] and a statement indicating that the structure "essentially complies with the Southern Building Code." Once an application is received, the property may be reviewed by the Insurance Services Office, New York, or other designated review organization. Such a review may include an on-site visit to determine whether there are any features, construction, occupancy, or physical hazards which may cause the application to be declined.

Field reports and rating details are examined by the Association to determine whether the property meets reasonable underwriting standards, including:

- reasonable relationship of the insurance coverage to the actual cash value of the property

- physical condition of the property (construction, maintenance, general deterioration);

- present use or housekeeping;

- violation of law, public policy, morals, and the character or integrity of the property owner or occupant. [16]

Losses reported to the Association are handled by the Association and its retained adjusters. In catastrophes such as Hurricane Hugo the Association estimates its cash needs and levies a special assessment on the Association members in order to have sufficient funds on hand. According to Association Manager Charles E. Koon, initial estimates of cash needs ran as high as $400,000,000; the Association in fact levied a $100,000,000 assessment soon after the storm struck. [17]

While the total number of the Association's policies (5,820) before the storm was small relative to the total number of structures in the coastal area, total potential liability for insurance in force was $920.3 million, an average of over $158,000 per policy.

As of June 30, 1990, 3,821 claims had been assigned by the Association to adjusters, and the Association had closed 98% (3,734), including slightly more than 18% without payment. The Association had closed 3,060 with payment, totalling $88,917,956 before adjusters' expenses of $3,767,551, for total payments of $92,685,507. Average claim payments, including adjusters' expenses, were $30,289. See Table 3.

Using claims data counted from the Association's Catastrophic Loss Register, the distribution of 3,736 claims among coastal area counties and communities as of the beginning of January 1990 is shown in Appendix F. Claims were made on over 90% of the policies from Folly Beach, Sullivans Island, Isle of Palms, Pawleys Island, the Litchfield Beach area, and Garden City, including 100% of the policies in force in Isle of Palms and the Litchfield Beach area. While the percentages of claims fall off the greater the distance from the eye of the storm, nevertheless they were strikingly high in light of the relatively low wind speeds in areas such as Myrtle Beach and North Myrtle Beach (84 mph maximum gust; 70 mph fastest-mile @ 33 feet), and Kiawah Island.

The files of the Association are extraordinarily rich in visual, analytical, and financial detail. Adjusters photographed each property extensively, estimated flooding vs. wind damages, and where wind losses were determined, provided detailed estimates of the cost to repair or to replace damaged or destroyed structures and contents. In preparing this paper, the author had but two days to study the Association's files. From that cursory review, however, he is convinced that the files would be an extraordinary source of data for researchers interested in building greater wind resistance into structures in high-wind environments and reducing the damages from windstorms. No comparable combination of regulatory and financial pressure or intervention in the market exists in South Carolina and most other states regarding wind resistance of coastal construction as in the flood insurance arena. Two notable exceptions are found in the Texas State Board of Insurance Inspection Program and New York's insurance renewal inspection and retrofit program. Efforts to effect change elsewhere have been voluntary and apparently slow to catch on.

TABLE 3

SOUTH CAROLINA WINDSTORM INSURANCE COVERAGE AND CLAIMS PAYMENTS FOR HURRICANE HUGO
(Sept. 1989 - June 30, 1990)

| Class | Insurance in Force | No. of Policies | Averages |
|---|---|---|---|
| Dwellings | $627,157,000 | 4,670 | $134,295 |
| Mobile Homes | $275,000 | 9 | $30,556 |
| Commercial | $292,868,000 | 1,141 | $256,677 |
| TOTALS | $920,300,000 | 5,820 | $158,127 |

Claims Summary

| | |
|---|---|
| Total Claims Reported | 3,821 |
| Total Claims Closed | 3,734 |
| Closed Without Payment | 674 |
| Closed and Reopened | 571 |
| Reopened and Closed | 520 |
| Closed With Payment | 3,060 |
| Total Claim Payments | $88,917,956 |
| Adjusters' Expenses | $3,767,551 |
| Total Claim Payments & Adjusters Expenses | $92,685,507 |
| Average Claim Payment | $29,058 |
| Avg. Payment w/ Expense | $30,289 |

Source: South Carolina Windstorm and Hail Underwriting Association data as of June 30, 1990.

Construction code groups such as the Southern Building Code Congress International work diligently to improve and publish performance and forthcoming prescriptive codes for coastal construction, and to educate builders and building officials, but response is totally voluntary. Enforcement of the wind resistance provisions of the building code still remain a local option in South Carolina and several other states.

As a general observation, neither lending institutions nor property and casualty insurance companies exert their considerable potential influence over the real estate market to ensure that properties that they finance or insure are built so as to reduce wind damages. In regulating where there is social and market resistance to construction standards, such as in South Carolina and many other states, the lending and insurance industries could be very effective in reducing damages by requiring better building practices as a condition of construction or mortgage loans and of insurance, and would probably enhance their own profitability in doing so. Ironically, just as building booms on the coasts of the United States increased in the 1960s and 1970s, many insurance companies reduced or eliminated their engineering departments--and thereby eliminated one potential means to prevent and reduce future damages.

The current often-used practice of accepting coastal construction plans sealed by an architect or engineer, or accepting a local government's certificate of occupancy as evidence of compliance with construction codes, has proven time after time to be inadequate. The failure of those practices and the inadequacy of most coastal community code enforcement programs were major contributing factors in creation of the Texas windstorm inspection program. One potential economic disincentive would be insurance company rates that reflect the quality of construction. The higher the quality of materials used and the greater the attention to details to reduce wind and flooding damages, the lower the premiums; and vice versa. Even where insurance companies may retain engineering firms to inspect properties to be insured, the inspection may be limited to the roof and exterior of the building after the frame and roof have been covered. Typically they do not inspect the frame, rafters, fasteners, or other factors in good coastal construction practice, because this is deemed too costly. Rather, they and the insurance company rely on local officials to enforce applicable codes. Too often this reliance is misplaced. The interdependence of the insurance sector with good code enforcement is readily evident. As a minimum, insurance companies would serve their own interests well to encourage, to educate, and to bring pressure on local government in all branches (executive, legislative, and judicial) to back good code enforcement.

## ENDNOTES

1. National Conference of States on Building Codes and Standards, Inc., "Preliminary Report -- Disaster Site Investigation of Manufactured Homes", Dec. 1989, Herndon, VA 22070.

2. Harlan, M.R. and Lindbergh, C., An Earthquake Vulnerability Analysis of the Charleston, South Carolina, Area. Department of Civil Engineering Technical Report CE-88-1, The Citadel, Charleston, S.C., 1988.

3. Adapted from Sparks, PR., "The Risk of Hurricane Wind Damage to Buildings in South Carolina -- A White Paper", Nov. 1988, Clemson University, Clemson, S.C.

4. Act of June 7, 1988, 1988 S.C. Acts 634, S.C. Stat. 5130.

5. South Carolina Coastal Council, Rules and Regulations, §R.30-1(C)(31) (Final Draft), Aug. 18, 1989.

6. Myrtle Beach and Vicinity, Horry and Georgetown Counties-South Carolina, Final Feasibility Report on Storm Damage Reduction. June 1988, U.S. Army Corps of Engineers, Charleston District, S.C.

7. See, e.g., Strobel, Carolina D., The Economic Impact of Proposed Coastal Setback and Renourishment Legislation of South Carolina, 1988, University of South Carolina, Columbia.

8. South Carolina Coastal Council, Homes and Businesses Affected by the No-Construction Zone -- state-wide totals, Undated.

8* Under the National Flood Insurance Program flood insurance is available from two sources: directly from the Federal Insurance Administration (the direct program), and secondly from individual insurance companies in the voluntary property and casualty insurance market (the Write Your Own program).

9. See Rogers, Spencer M., Jr., Coastal Erosion Issues in Flood Hazard Mapping, 1989, North Carolina State University and UNC Sea Grant Marine Advisory Service, Kure Beach, N.C.

10. §38-75-330, South Carolina Insurance Laws (1988).

11. Ibid., §38-75-370

12. Beach Plan, South Carolina Windstorm & Hail Underwriting Association, Manual of Rules and Procedures (September 1, 1985), herein "Manual", §VIII.

13. Endnote 8, §38-75-310 (5).

14. Manual, §§II.4. & 5.

15. Manual, §III.1.(d)

16. Manual, §III.3.(b)

17. SCWHUA Financial Statements - 1989 Association Year

## APPENDIX A

# SURVEY OF DAMAGES – FOLLY BEACH TO NORTH MYRTLE BEACH

This Appendix is a partial survey of damages caused by Hurricane Hugo in communities from Folly Beach to North Myrtle Beach. It is based on observations of the author and those of coastal engineer Hsiang Wang of Florida State University and Billy Manning, Chief Engineer of the Southern Building Code Congress International.

### Folly Beach.

On a coastal barrier island south of Charleston, Folly Beach was on the left forward quadrant of the storm as Hugo approached the mainland. Storm surge levels of about 12 feet were measured. Severe storm surge damages were experienced in the central and eastern portions of the island. Virtually all single family homes in the first tier fronting the ocean sustained damages; many were destroyed. Damages from both surge and wave action were evident in the crushing of some buildings and the flotation of others off their foundations. First floor flooding was common in the second tier and to a lesser extent in the third tier.

The most visible commercial structure, the Holiday Inn, sits well seaward of the residential building line on filled land protected by a reinforced concrete retaining wall and heavy revetment. Structurally the building withstood the forces of the storm apparently very well. The ground level was enclosed and, according to the local building official, designed to be dedicated to the storm. It was. Virtually all facilities on the ground level were destroyed. Erosion behind the retaining wall caused the concrete deck to collapse and undermined the swimming pool. In this respect the damages were very similar to those experienced by hotels and condominiums in the Myrtle Beach area.

### Sullivans Island.

A coastal barrier island northeast of Charleston, Sullivans Island was for a long time part of the coastal defenses for Charleston Harbor; several of the houses on the island date from 1810-1820 and are part of the historical heritage of the area.

The island experienced heavy water and wind damages during the storm. Storm surge on the island was about 13 feet above mean sea level. Wind direction as the storm approached and passed was predominantly from the northeast, causing particularly heavy damages and destruction on the eastern end of the island. The west end of the island was less affected by flooding, and benefitted from the wide beach that had accreted north of the harbor entrance jetty.

Nearly all of the older houses seaward of Marshall Avenue, which runs parallel to the beach at the northern end of the island, were destroyed, either by wave action or by floating off their foundations. These houses were typically on shallow piles, concrete block piers, or slabs on grade, with ground floor elevations of 12 feet or less above mean sea level. In the recovery period the town contracted to demolish nearly 100 of the 950 residences on the island; many more were destroyed in the storm and became part of the general storm debris.

**Isle of Palms.**
Part of the same coastal barrier island chain as Sullivans Island but separated by Breach Inlet, the Isle of Palms experienced storm surge of up to 15 feet above mean sea level. Flooding damages on the island were concentrated in two areas; between 10th Avenue and 14th Avenue in the island's principal commercial zone; and the near ocean residential properties from 42d Avenue to 57th Avenue. Below 10th Avenue to the southwest, and between 14th Avenue and 42d Avenue, the unusual width of the beach seaward of the houses appears to have been a major factor in the reduced flooding damages.

From 14th Avenue to 41st Avenue all of the structures were set back quite far from the beach, with an unusually wide beach and low, but well defined dunes. Above 42d Avenue the numbered avenues extend close to the beach, perpendicular to the beach and to Route 703, the highway running the length of the island. Houses located at the ends of these avenues, and sometimes those in the second and third tiers back, were destroyed or heavily damaged.

Many of the structures in this area were slab on grade, elevated on unreinforced concrete block, or elevated on lightly reinforced concrete block piers with shallow footings, and almost invariably were built before the regulations of the National Flood Insurance Program were enforced. Typically, any structure that could not let water pass beneath it was either damaged or destroyed by dynamic water forces or lifted off its foundation.

Water damages in the Wild Dunes planned unit development did not appear to be extensive. Built to comply with the NFIP regulations, the buildings were elevated properly -- structurally they performed well. Air conditioners, hot water heaters, washing machines and dryers, and any other equipment, utilities, facilities, or storage areas located or enclosed at ground level were destroyed. Deck stairs, walkways and similar structures were heavily damaged in this area; houses on the oceanfront experienced considerable foundation scour, but because of adequate piling size and soil penetration, none collapsed.

**Moores Landing and Romain Retreat.**
Subdivisions southwest of Bulls' Bay, off Seewee Bay and north of Charleston, Moores Landing and Romain Retreat experienced some of the highest surge levels in the storm, nearly 20 feet above mean sea level. Just north of the estimated path of the right eyewall of the hurricane, they also experienced some of the highest wind speeds of the storm. Devastation of houses in both subdivisions was nearly total. Houses as far as 1,000 feet from Bull's Bay and elevated 18 feet above mean sea level were floated off their foundations.

**McClellanville.**
Located on the north side of Bull's Bay, this village, created by plantation owners who had lost their summer homes in the great hurricane of 1822, sustained heavy flooding damages to frame and manufactured homes which predominate, to the two offices, and to the metal frame, metal clad buildings housing commercial fishing operations. The town is remembered best for the 1,125 people who sought refuge in the Lincoln High School only to find water rising in the cafeteria, band room, gymnasium, and class rooms where they stayed. After the storm a survey determined that the school was 10 feet lower than had been recorded.

**Pawleys Island.**
A coastal barrier island fronting Georgetown County, Pawleys Island is a relatively old residential community, self-described as "arrogantly shabby". Dunes on the central part of the island rise fairly high and apparently were not overtopped, even though the island had about 13 feet of storm surge. Elevations are lower at either end of the island, and the south end is also quite narrow. At the south end the concrete pier foundations of several houses were undermined and collapsed; at least two of the houses floated across the bay behind the island and lodged in the wetlands adjacent to the mainland.

Residential construction is largely pre-FIRM, that is, before the NFIP regulations were instituted. Quality of construction, in general, is described by one coastal engineer as "marginal at best". This description was borne out in one instance when the author watched apparently out-of-area contractors repairing one house using materials and building techniques that were highly inappropriate for the dynamic environment, and which apparently did not comply with the building code, much less with good coastal construction practice.

**Garden City.**
An unincorporated part of Georgetown County, Garden City is predominantly residential, with some condominiums, and a planned community at its southern end. Water damages were extensive, some found as much as 1,500 feet landward, with surge measured about 13 feet above mean sea level. South of Atlantic Avenue on the north end, for a distance of about five blocks, nearly every house and commercial building in the first tier was destroyed. Structures were 10-30 years old, most on shallow concrete footings, concrete block piers, or slab on grade. The destruction was apparently caused by surge, wave action and storm scour around foundations.

Older buildings along the shorefront suffered similar destruction and damage. According to coastal engineer Hsiang Wang, newer construction, particularly buildings built in the last two years, survived with relatively minor water damage. He noted one exception, a concrete 2-story structure owned by a local architect. The building had heavy reinforced concrete roof beams and prefabricated concrete walls. However, it was elevated on piers resting on a poured shallow concrete foundation. Waves apparently caused the piers on the front to move off the foundation, and the piers on the back to buckle, causing the house to collapse. From Garden City to North Myrtle Beach the Grand Strand is described by Professor Peter

Sparks as "the greatest concentration of under-designed medium and high-rise buildings anywhere in the country, possibly in the world."

**Surfside.**

The oceanfront of Surfside is built up with highrise buildings and condominiums. With surge measured at 13 feet above mean sea level any enclosed areas at ground level were destroyed or heavily damaged. From Surfside north into Myrtle Beach seawalls and revetments fronting the buildings were heavily damaged. Scour behind the seawalls and revetments frequently undermined swimming pools, decks, walkways. Septic systems, drain field and sewer lines also were commonly exposed by scour.

**Myrtle Beach.**

Myrtle Beach is slightly higher than Surfside to the south and North Myrtle Beach to the north. As a result, Myrtle Beach experienced lighter water damages from 13 ft. surge than the flanking communities. Heavy seawall and revetment damage was similar to that in Surfside. Swimming pools were somewhat less damaged than in Surfside, but nevertheless required major repairs and permitting approval by the South Carolina Coastal Commission. The city lost about 150 wooden beach access walkways because of the surge.

**North Myrtle Beach.**

The 13 ft. storm surge caused extensive water damages and destruction in North Myrtle Beach wherever buildings were inadequately elevated. The types of failure were similar to those experienced elsewhere on the coast. Houses on slab foundations frequently collapsed from wave attack or floated off their foundation. No multi-story buildings collapsed. But first floor rooms and other space were either swept clear of utilities, facilities, and furnishings as waves went through the structures, or furnishings, exterior debris, and sand piled up in the rooms and passageways if the waves did not break through the building.

APPENDIX B

# STATUS OF CONSTRUCTION CODE ADOPTION IN SOUTH CAROLINA (COUNTIES)

| Code Adopted | Code Not Adopted |
|---|---|
| Aiken | Abbeville |
| Anderson | Allendale |
| Beaufort | Bamberg |
| Charleston | Barnwell |
| Colleton | Berkeley |
| Dorchester (lower half) | Calhoun |
| Edgefield | Cherokee |
| Georgetown | Chester |
| Greenville | Chesterfield |
| Horry | Clarendon |
| Jasper | Darlington |
| Lee | Dillon |
| Lexington | Dorchester (upper half) |
| Pickens | Fairfield |
| Richland | Florence |
| Spartanburg | Greenwood |
| York | Hampton |
| | Kershaw |
| | Lancaster |
| | Laurens |
| | McCormick |
| | Marion |
| | Marlboro |
| | Newberry |
| | Oconee |
| | Orangeburg |
| | Saluda |
| | Sumter |
| | Union |
| | Williamsburg |

Source: The Establishment of Uniform Minimum Building Standards in South Carolina, Citizens & Organizations for Minimum Building Standards (COMBS), Citadel Station, Charleston, S.C., 1989.

## APPENDIX C

# SYNOPSIS OF CONSTRUCTION CODE LEGISLATION

A bill introduced and considered in the 1990 session of the General Assembly, if enacted would have required all counties and defined municipalities to adopt construction codes within a specified time from July 1, 1992 to July 1, 1994, depending on the community's population.

| As introduced the bill would: | As reported out by the Senate Committee on Judiciary, S. 460: |
|---|---|
| 1. Require all municipalities and counties to adopt the latest editions of the Standard Building, Gas, Plumbing, Mechanical, and Fire Prevention Codes, and the National Electric Code, including any appendices specified in the adopting ordinance; | 1. Similar, except that code appendices may be adopted as needed by municipalities and counties, but must be referenced in the adopting ordinance. |
| 2. Authorize municipalities and counties to adopt the latest editions of the Standard Housing, Existing Buildings, Swimming Pool, and Excavation and Grading Codes, and the CABO One and Two Family Dwelling Code, including any appendices specified in the adopting ordinance; | 2. Similar, except that code appendices may be adopted as needed by municipalities and counties, but must be referenced in the adopting ordinance. |
| 3. Redefine the membership of the 13-member S.C. Building Codes Council; | 3. Similar. |
| 4. Require municipalities and counties to appoint a building official, and authorize employment of other personnel needed to perform inspections and other duties; authorize fees to be prescribed for construction permits and inspections; and authorize regional agreements for issuance of construction permits and code enforcement; | 4. Similar. |
| 5. Make violations of codes misdemeanors subject to fines or imprisonment; and authorize officials and individuals to apply for injunctive relief, mandamus, or other appropriate [civil] proceeding; | 5. Similar. |
| 6. Authorize municipalities and counties to appropriate and expend funds to implement the provisions; and | 6. Similar |

**Appendix C**
**(Continued)**

| | |
|---|---|
| 7. Have no effect on:<br>a. State agencies and facilities;<br>b. The powers and authority of the State Fire Marshal. | 7. Similar |
| 8. Companion legislation was introduced that would require all code enforcement officers in South Carolina to be certified and to maintain their proficiency through continuing education. | 8. Requires certification of building codes enforcement officers in order to practice as such: misdemeanor for violations; applicant must provide valid certification by a recognized code organization or testing agency; local jurisdiction may impose additional requirements. Also would require all code enforcement officers in South Carolina to be certified and to maintain their proficiency through continuing education. |
| 9. No exception for "farm structures" was included in the bill. | 9. Exempts "farm structures" from building codes provisions; owners must file affidavit with local building official stating that structure being built as farm structure; misdemeanor for violation. |

APPENDIX D

## LIST OF KNOWN STORMS AFFECTING THE SOUTH CAROLINA COAST (1800 - 1980

| DATE OF STORM | STORM'S HIGHEST CATEGORY | HIGHEST CATEGORY SC. [1] | AREA MOST AFFECTED IN SC. |
|---|---|---|---|
| 1804 - 3-9 Sep | | | S.C. coast near Charleston |
| 1811 - 10 Sep | | | Charleston |
| 1813 - 27 Aug | | | Charleston |
| 1814 - 1 Jul | | | Charleston |
| 1815 - 28 Sep | | | S.C. coast |
| 1822 - Aug | | | S.C. coast |
| 1830 - 12-17 Aug | | | Near Charleston |
| 1837 - 1 Sep | | | Charleston |
| 1837 - 8-9 Oct | | | Charleston |
| 1841 - 16 Sep | | | South Carolina |
| 1844 - 14 Sep | | | Charleston |
| 1846 - 16 Aug | | | S.C. coast |
| 1850 - 24 Aug | | | Charleston |
| 1851 - 24 Aug | | | Charleston |
| 1852 - 27 Aug | | | Charleston |
| 1854 - 7-8 Sep | | | Charleston & south |
| 1871 - 16-18 Aug | | | South Carolina |
| 1874 - 28 Sep | | | Charleston & SC coast |
| 1878 - 11-12 Sep | | | S.C. coast |
| 1881 - 21-27 Aug | | | South Carolina |
| 1882 - 11 Oct | | | S.C. coast |
| 1885 - 24-25 Aug | | | Charleston |
| 1888 - 11 Oct | | | S.C. coast |
| 1889 - 23 Sep | | | S.C. coast |
| 1893 - 22-30 Aug | | | Charleston & SC coast |
| 1894 - 26-27 Sep | | | S.C. coast |
| 1898 - 25 Sep-7 Oct | | | Carolina coast |
| 1904 - 15 Sep | 1 | 1 | Georgetown, N.E. SC coast |
| 1906 - 17 Sep | 3 | 3 | Georgetown, cen. SC coast |
| 1906 - 20 Oct | 2 | - | Charleston & S.C. coast |
| 1907 - 27-29 Sep | - | - | South Carolina |
| 1910 - 19 Oct | 3 | - | S.C. coast |
| 1911 - 27-28 Aug | 2 | 2 | Charleston, south |
| 1916 - 13-14 Jul | 1 | 1 | Charleston & SC coast |
| 1920 - 20 Sep | 1 | - | North & South Carolina |
| 1924 - 16-17 Sep | 1 | - | South Carolina |
| 1927 - 1-3 Oct | - | - | Lower S.C. coast |
| 1928 - 10-11 Aug | - | - | N.E. South Carolina |
| 1928 - 14-15 Aug | 2 | - | South Carolina |
| 1928 - 17-19 Sep | 4 | 1 | Charleston & S.C. coast |
| 1929 - 1-2 Oct | 3 | - | N.E. thru S.C. coast |
| 1934 - 21-25 Jul | 2 | - | Off coast of S.C. |

Appendix D (continued)

| DATE OF STORM | STORM'S HIGHEST CATEGORY | HIGHEST CATEGORY SC. [1] | AREA MOST AFFECTED IN SC. |
|---|---|---|---|
| 1935 - 5 Sep | 5 | - | South Carolina |
| 1940 - 11 Aug | 1 | - | South of Charleston |
| 1944 - 19 Oct | 3 | - | Near Beaufort |
| 1945 - 17 Sep | 3 | - | South of Charleston |
| 1947 - 15 Oct | 2 | 2 | South Carolina |
| 1949 - 28 Aug | 1 | 1 | Eastern Ga. & N.W. S. Car. |
| 1952 - 31 Aug (Able) | 1 | 1 | Beaufort, central S.C. |
| 1954 - 15 Oct (Hazel) | 4 | 4 | Georgetown, north |
| 1955 - 12 Aug (Connie) | 3 | - | Georgetown, north |
| 1955 - 17 Aug (Diane) | 1 | - | Georgetown, north |
| 1955 - 19 Sep (Ione) | 3 | - | Georgetown, north |
| 1958 - 27 Sep (Gracie) | 3 | 3 | Georgetown, south |
| 1962 - 18 Oct (Ella) | - | - | Folly Island (slight) |
| 1963 - 25 Oct (Ginny) | - | - | Light erosion, SC beaches |
| 1964 - 30 Oct (Cleo) | 2 | 2 | Charleston - low tide surge |
| 1966 - 19 Jun (Alma) | 2 | - | Charleston - flooding |
| 1968 - 7 Jun (Abby) | - | - | Heavy rains, beach erosion |
| 1968 - 19 Oct (Gladys) | 2 | - | Moderate beach erosion |
| 1972 - 20-21 Jun (Agnes) | 1 | - | Little effect in S.C. |
| 1979 - 5 Sep (David) | 2 | 2 | 4 tornadoes Grand Strand |

[1] Classification according to the Saffir/Simpson damage potential scale. A dash (-) indicates a tropical storm.

Source: Myrtle Beach and Vicinity, Horry and Georgetown Counties-South Carolina, Final Feasibility Report on Storm Damage Reduction, June 1988, U.S. Army Corps of Engineers, Charleston District, S.C.

APPENDIX E

## PROPERTY VALUES
## FRONT ROW BEACH PROPERTIES
## HORRY COUNTY AND NORTHERN GEORGETOWN COUNTIES, S.C.

| No. of Strucs. | Struc'l Value ($ mill.) | Land Value ($ mill.) | Seawall Value ($ mill.) | Pool Value ($ mill.) | Total Value ($ mill.) |
|---|---|---|---|---|---|
| | | HORRY COUNTY | | | |
| 1,210 | $1,164.6 | $ 251.1 | $ 7.3 | $ 17.7 | $1,440.7 |
| | | GEORGETOWN COUNTY | | | |
| 189 | $ 20.2 | $ 26.8 | $ 0.5 | $ 0.3 | $ 4.7 |
| | | TOTAL | | | |
| 1,399 | $1,184.8 | $ 277.9 | $ 7.8 | $ 18.0 | $1,488.5 |

Source: Myrtle Beach and Vicinity, Horry and Georgetown Counties - South Carolina, Final Feasibility Report on Storm Damage Reduction, June 1988, U.S. Army Corps of Engineers, Charleston District, S.C.

Based on these and other statistics, the Army Corps of Engineers' Charleston District concluded that plans to renourish the beaches from North Myrtle Beach to northern Georgetown County to provide protection from a 5-year surge level event would have the following benefit:cost ratios:

| | |
|---|---|
| North Myrtle Beach | 5.8 to 1 |
| Myrtle Beach | 2.1 to 1 |
| Surfside/Garden City | 6.0 to 1 |
| Total Reach | 4.5 to 1 |

Total first costs for the project were estimated at $45,248,000; periodic nourishment costs were estimated at $929,000, $325,000 of which would be the nonfederal share. The project was estimated to save $16,600,000 annually in damages to shoreline structures, and to provide an additional $5,400,000 in average annual recreation benefits, or $22,000,000 in average annual benefits. The total average annual cost was estimated to be $4,894,000.

## APPENDIX F

# DISTRIBUTION OF WINDSTORM INSURANCE CLAIMS IN SOUTH CAROLINA FOR HURRICANE HUGO

| County/Community | In Force Liability | Number of Policies | No. Claims Assigned (1/6/90) | Percent Claims/ Policies |
|---|---|---|---|---|
| CHARLESTON COUNTY | | | | |
| Kiawah | $38,840,000 | 199 | 109 | 55% |
| Folly Island | $33,958,000 | 455 | 409 | 90% |
| Sullivans Island | $35,479,000 | 259 | 231 | 89% |
| Isle of Palms | $87,304,000 | 576 | 476 | 100% |
| Rest of County | $22,229,000 | 112 | 65 | 58% |
| Total Charleston County | $217,810,000 | 1,601 | 1,389 | 87% |
| GEORGETOWN COUNTY | | | | |
| Pawleys Island | $41,253,000 | 299 | 276 | 92% |
| Litchfield Beach | $32,275,000 | 196 | 196 | 100% |
| Garden City | $60,249,000 | 514 | 468 | 91% |
| Rest of County | $22,977,000 | 65 | 47 | 72% |
| Total Georgetown County | $156,754,000 | 1,074 | 992 | 92% |
| HORRY COUNTY | | | | |
| Surfside Beach | $17,461,000 | 207 | 151 | 73% |
| Myrtle Beach | $171,830,000 | 620 | 263 | 42% |
| North Myrtle Beach | $145,737,000 | 1,280 | 549 | 43% |
| Rest of County | $1,371,000 | 25 | ? | |
| Total Horry County | $336,399,000 | 2,132 | 963 | 45% |
| TOTAL STATE OF SOUTH CAROLINA | | | | |
| Dwellings | $627,157,000 | 4,670 | | |
| Mobile Homes | $275,000 | 9 | | |
| Commercial | $292,868,000 | 1,141 | | |
| TOTAL | $920,300,000 | 5,820 | 3,736 | 64% |