Fire Building Standards

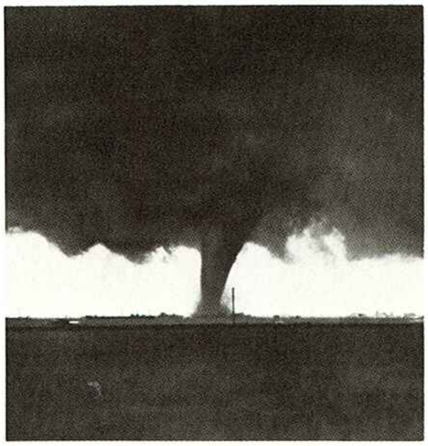
BUILDING LOSSES FROM NATURAL HAZARDS:

YESTERDAY, TODAY AND TOMORROW

TABLE OF CONTENTS

This material is being publicly disseminated under National Science Foundation Grant No. ENV-77-08435. It is based upon research supported by NSF Grant Nos. AEN-74-23993, ENV-76-24658 and ERP-75-09998. Any opinions, findings and conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Science Foundation.

INTRODUCTION



The complexities of today's society make it more essential than ever for us to continually re-evaluate our priorities and establish new ones. At the same time, they make it infinitely more difficult to do so.

Yet—regardless of who is doing the prioritizing—the manner in which most individuals and institutions make such value judgements often isn't much different than it was before any of us first heard of "risk/benefit analysis," "accountability," "tradeoffs" or "cost effectiveness."

When a loved one dies of cancer, it's suddenly our crusade. When enough cities suffer enough flood damage, dam building and flood insurance become the priorities of the day. And when a sufficiently devastating number of landslides occur, at least local building codes are likely to be strengthened and enforcement procedures tightened.

In the case of our most destructive natural hazards, however, there's mounting evidence that such an opportunistic approach is no longer either practical or acceptable.

Hazard Costs Great

According to one expert, the 30 most common natural hazards annually account for direct costs of at least one percent of our gross national product and countless millions of dollars more in related ones. Sizeable expenditures are being allocated for controlling them by government at all levels and by the private sector. Nevertheless, the costs are continuing to grow at an accelerating rate. There are some indications, in fact, that a few efforts targeted at minimizing or preventing them may, in the long run, lead to even greater losses.

Unless fundamental changes are made, the annual cost of destruction from these hazards—even after discounting for inflation—will go up over 85 percent between 1970 and the year 2000. Further, in a not-too-far-fetched scenario based upon past history, a Chicago tornado, a Los Angeles earthquake or a Miami Beach hurricane would represent a disaster of unparalleled proportions. If two or three such events were to occur within a couple of years of each other, the toll, in terms of lost lives and impact upon our economic system, could well be catastrophic.

NSF Grants Made

Recognizing the implications of this, in July, 1975, the National Science Foundation made two grants to the J. H. Wiggins Company of Redondo Beach, California, and added a third in September, 1976. The firm was charged with responsibility for development of forecasts associated with our most destructive natural hazards which could be used as a basis for establishing research priorities and public policy directions. The principal study reports are listed in the references to this document.

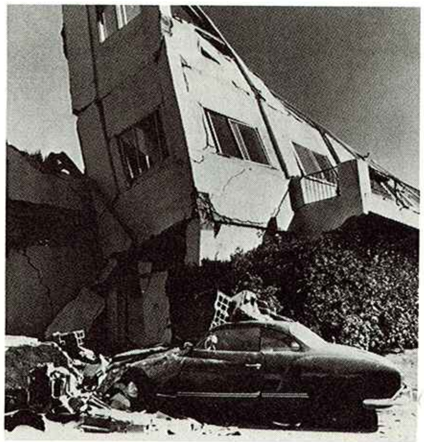
Because the studies were limited to building damage and related losses, the nine hazards examined were selected in recognition of their historic impact on such structures. They are: earthquake, landslide, expansive soil, hurricane wind/storm surge, tornado, riverine flood, local wind, local flood and tsunami.

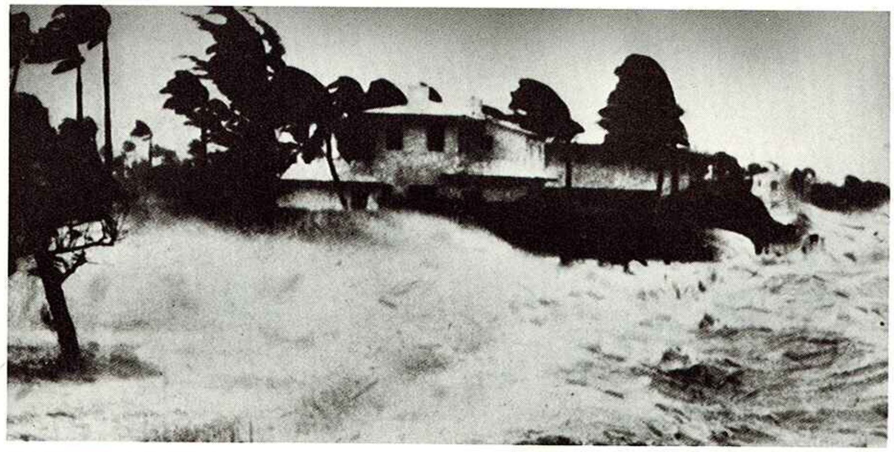
The first phase of these studies, summarized in this document, deals solely with damage to buildings. The second, which is referenced, addresses other types of losses known to often increase the impact of a hazard many-fold. Covered in this second phase are building contents and income losses, transportation effects due to dislocations of suppliers, homelessness and unemployment, as well as costs of applying certain mitigations.

Each of the hazards was first modeled and programmed on computers to provide estimates of annual and, in some cases, sudden catastrophic losses which might impact upon the nation's building wealth between 1970 and 2000. Computer modeling also was applied to various mitigations which conceivably could be developed and implemented to reduce loss. Potential loss reductions were then projected and evaluations made on both state and national bases.

New Models Created

Because only fragmentary information on the relationship of these hazards to economic loss had heretofore been publicly available, except in the case of riverine flood, it was necessary to construct eight all-new models. Even the existing flood model failed to identify or project past losses by region, requir-





ing Wiggins to substantially expand it. A vital first step in the studies, therefore, was to estimate as accurately as possible the building losses which might have been caused by recorded past events, to provide a basis for forecasting the future.

It is likely these estimates are low in many instances because portions of the models often were based upon projections from loss experiences which frequently were inaccurate or incomplete. Annual average flood losses, for example, are "officially" estimated to be less than half of what most experts agree they really are. The official damage estimate within one subdivision, made just after the 1971 San Fernando Earthquake, later proved to be less than 10 percent of a later, more detailed conservative count, according to D. Earl Jones, Jr., of the Department of Housing and Urban Development.

In the case of wind, for which no base line figures existed, damage estimates were based on expectations of a panel of recognized experts who considered wind velocity and varying building strengths. Their assessments are considered to be at least as reliable as any previously available data.

Many Variables Excluded

Many variables associated with each of these hazards were reluctantly excluded from the models because it was impossible to measure their influence on a long-term basis. It was impractical, for example, to determine how much more vulnerable areas which are sinking, due to water and mineral extraction, will be in future years to storm surge and riverine or local flood.

Using the completed models, the natural hazards were ranked to show both average annual loss expectancy and the potential for sudden catastrophic loss in a state or region.

Several Scenarios Created

A number of scenarios of extreme events—such as the potential cost if the 1906 San Francisco Earthquake reoccurred in 2000—were also modeled to provide additional perspective. This was felt to be necessary because potential sudden earthquake losses might well be from five to 20 times greater than those from the largest forseeable flood, even though reported annual flood losses have been from 10 to 25 times greater than losses from earthquake during this century.

With the development of computer models which include the hazard-exposure-vulnerability components of risk, it became feasible to estimate the effectiveness of various mitigations for reducing average annual and sudden catastrophic losses.

It is the intent of these studies to reveal primarily the percentage by which damage might be reduced if some of the most frequently discussed or more promising mitigations were to be applied. It is hoped this, in turn, will facilitate the establishment of research and budget priorities on a more educated basis than has to date been possible. It is always conceivable, however, that once under way, research will take unanticipated directions and uncover effective, but as yet unknown, mitigations.

It should be further noted that the potential benefits from reducing losses caused by one hazard often will reduce the impact of others. For example, employment of mitigations which increase a building's resistance to earthquake will often improve its ability to resist damage from tornado, high wind, various kinds of soil movement and landslide, which together cause annualized damage in excess of $6 billion.

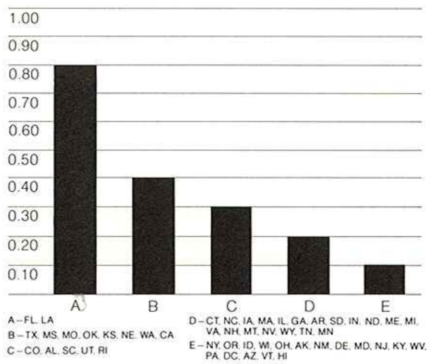
1978 Dollar Values

All of the monetary values cited in this study are in terms of 1978 dollars. No attempt at forecasting inflation has been made.

It is hoped this document and the far more comprehensive studies it summarizes will help point the way to identifying research priorities, budgetary allocations and public policies targeted at effectively dealing with a significant national problem. It is essential that meaningful steps be taken during this decade to reduce the increasingly devastating losses America faces from earth, air and water related hazards.

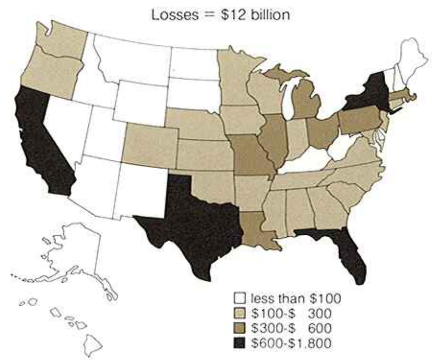
OVERVIEW

PROJECTED ANNUALIZED BUILDING LOSSES BY STATE FROM NINE NATURAL HAZARDS UNDER 1980 CONDITIONS IN TERMS OF CENTS PER HUNDRED DOLLARS EXPOSED



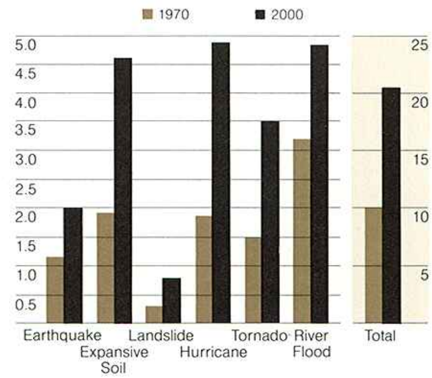
PROJECTED TOTAL ANNUALIZED BUILDING LOSSES BY STATE FROM NINE NATURAL HAZARDS UNDER 1980 CONDITIONS

(1978 dollars in millions)



AVERAGE TOTAL ANNUAL BUILDING LOSSES UNDER 1970 AND YEAR 2000 CONDITIONS

(1978 dollars in billions)



Unless significant new steps are taken, the cost of replacing or repairing buildings destroyed and damaged by the nine natural hazards studied, during a typical year, are likely to increase more than 85 percent in the 30-year period between 1970 and 2000.

The Wiggins studies estimate that, under average 1970 conditions, building losses from earthquake, expansive soil, landslide, riverine flood, hurricane wind/storm surge, tornado, local flood, local wind and tsunami would approximate 10.5 billion 1978 dollars. Compare this with the 4.5 billion 1978 dollars in building losses caused annually by fire. Unless appropriate mitigations are applied, these monetary figures are almost certain to reach approximately 19.5 billion in constant dollars annually beginning in 2000.

On the other hand, if the most effective mitigations against each hazard modeled in the studies were to be applied, beginning in 1980, total annual dollar losses could be reduced nearly 25 percent or approximately $5 billion, by 2000. In fact, this reduction represents over half the projected rise in dollar losses.

Figures Probably Low

Many of these figures are probably low because of the historically poor damage estimates on which portions of the models are based. Nevertheless, they are the most comprehensive assessments available to date. It should be noted, however, that these building loss estimates only represent the tip of the iceberg. Damage to infrastructure, such as roads and bridges, which is not covered by these studies, is believed to often equal that suffered by buildings. In addition, secondary losses, estimated in the next phase of these studies—in terms of building contents, income, transportation effect due to dislocation of suppliers, homelessness and unemployment—compound the figure even more.

During an average year, building damage from these hazards, per dollar exposed, is greatest in Florida and Louisiana. Also hard hit, in relation to their numbers of buildings, are Mississippi, Missouri, Kansas, Texas, Nebraska, Oklahoma, Washington and California. Using the same criteria, the states with the lowest damage rate from the hazards studied are the District of Columbia, Hawaii, Arizona, Vermont and Pennsylvania.

When viewed solely in terms of *total* damage to buildings from the hazards, California heads the list. Next come Florida, Texas, New York and Illinois. States sustaining the least dollar damage to their building stock are Vermont, Alaska and Wyoming.

Flood Damage Greatest

Although riverine flood causes the most damage to buildings today—an estimated $3 billion annually—hurricane wind/storm surge and expansive soil are likely to pass it up, becoming our No. 1 and 2 hazards by the year 2000, unless appropriate mitigations are applied.

While flood damage might even decline over the next few years, because of current emphasis on dam building and other flood control projects, destruction of buildings by hurricanes is expected to grow from today's almost $2 billion to about 5 billion constant dollars annually by 2000. This is largely due to population growth and movement, coastal development and higher construction values.

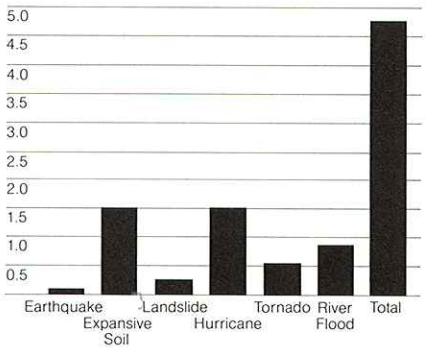
If nothing significant is done to prevent it, all damage from expansive soil could be almost equally devastating by the year 2000. The forecasts reveal that today's annual losses of $2 billion will mount to 4.5 billion 1978 dollars within the 30-year period studied unless something more is done. Ironically, the studies also reveal that expansive soil damage to new construction could be reduced as much as 85 percent by the year 2000, if stringent siting and building controls were mandated nationally beginning in 1980.

35% Reduction Possible

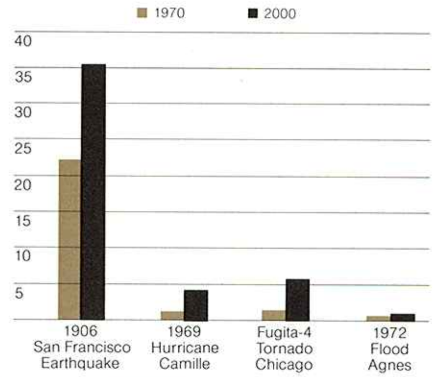
Mitigations studied could reduce annual damage to all buildings by 2000 as much as 35 percent in the case of expansive soil and varying amounts, depending upon the hazard, down to a still meaningful 11 percent in the case of earthquake. Even more substantial reductions could be realized, of course, should further research develop new, but presently unknown, mitigations.

The impact of infrequent, but devastating sudden losses upon our building stock and economy must also be taken into consideration. Granted that unless current efforts to develop a reliable early detection and warning system are successful, the state of current technology only makes it possible to reduce earthquake damage to buildings 11 percent. But this represents a sizeable saving in the event of a catastrophic occurence. If the 1906 San Francisco Earthquake reoccurred in the year 2000, it would cause damage to buildings in excess of 36 billion 1978 dollars, as well as about 5,000 deaths and 200,000 injuries, without even taking into account possible fire damage. But, if mitigations triggering an 11 percent reduction were begun in 1980, nearly $4 billion, 600 deaths and 24,000 injuries could be shaved from this amount.

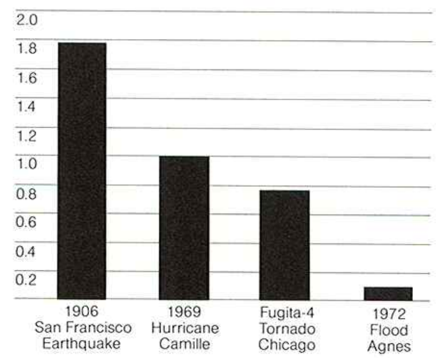
PROBABLE MAXIMUM ANNUAL LOSS REDUCTIONS FROM MITIGATIONS UNDER YEAR 2000 CONDITIONS
(1978 dollars in billions)



SCENARIO BUILDING LOSSES UNDER 1970 AND YEAR 2000 CONDITIONS
(1978 dollars in billions)



PROBABLE MAXIMUM SCENARIO LOSS REDUCTIONS FROM MITIGATIONS UNDER YEAR 2000 CONDITIONS
(1978 dollars in billions)



Similarly, if Hurricane Camille repeated its 1969 devastation in the year 2000, building damage would top 4 billion 1978 dollars and cause 200 to 400 deaths and 20,000 to 40,000 injuries. But if the most effective mitigations studied were to be applied beginning in 1980, damage could be reduced over $1 billion, 50 to 100 lives saved and 5,000 to 10,000 injuries avoided.

Another unfortunate consequence of the tendency to act only when a persistent, albeit less severe, hazard exists, is that homeowners who are literally wiped out by local flood or landslide seldom receive the degree of relief available to those hit by area-wide disasters, such as riverine flood or hurricane. The National Flood Insurance Program actually precludes recovery from localized flooding, despite the fact that thousands of families are hard hit by such occurrences each year. Further, it's a rare occasion when a home destroyed by landslide is either insured or covered by Federal or state disaster relief programs.

Some Pictures Difficult

It was not possible to develop as complete a picture of losses and mitigations pertaining to local flood, local wind and tsunami as it was in the case of the other six hazards:

(1) In practice, a 15-city sample proved too unrepresentative to inspire confidence in the findings of the local flood study, particularly in view of traditionally spotty reporting practices. Many experts felt the estimate of $350 million in building damage from local flooding during a typical year could well represent less than half the actual total. The accuracy of the subsequent projections and mitigations is, therefore, highly suspect.

(2) The wind panel utilized in Wiggins' hurricane, tornado and local wind studies found it exceedingly difficult to estimate typical damage which might be anticipated from varying degrees of less-than-hurricane velocity winds. Nevertheless, the model *does* reveal that local wind damage to buildings is most severe in Wyoming, Rhode Island, North and South Dakota and Colorado; that the damage amounts to at least 19 million 1978 dollars each year; and that, unless appropriate mitigations are applied, this is likely to increase about 120 percent by the year 2000. Population growth and higher building values are cited as the primary reasons for the size of this increase. If all new construction were required to be 50 percent more wind resistant, beginning in 1980, an annual reduction of nearly 15 percent could be realized by the year 2000, according to the model.

(3) Eighty-five tsunamis have attacked U.S. shores in the past 160 years. Nearly 60 percent of them hit Hawaii and over 35 percent California. Washington, Oregon and Alaska also have been hit by the giant seismic waves, generated by submarine earthquakes, volcanic eruptions or landslides around the Pacific Rim. There are many who believe the Eastern Seaboard and Gulf States may ultimately experience a similar phenomenon. The two most powerful tsunamis in recent years devastated Crescent City, California, and Hilo, Hawaii. Originating in the Eastern Aleutian Islands, the latter wave caused approximately 320 million 1978 dollars damage to buildings throughout Hawaii in April, 1946. Unfortunately, it was impossible to model future tsunami trends or attempt to develop potential mitigations.

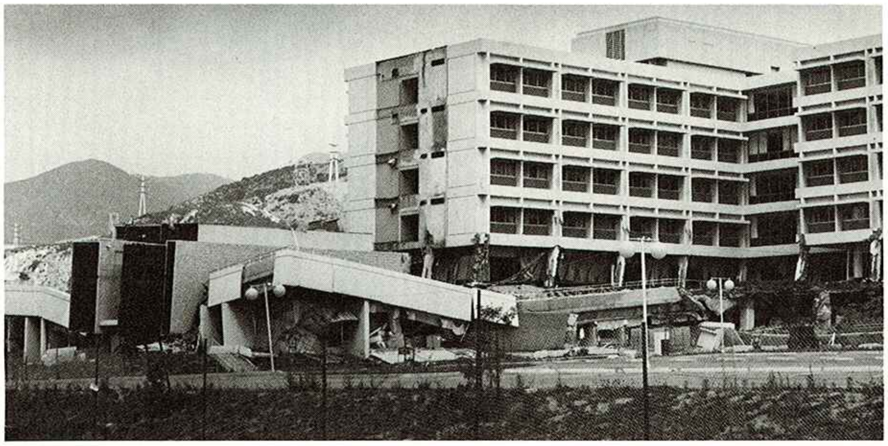
Deeper Study Needed

It is clear that a deeper study of these hazards should be undertaken to obtain more complete forecasts. In fact, it is evident from all the results of these pioneer studies that far more data is required about *all* natural hazards. There is a pressing need to accelerate the identification of hazardous locations, as well as to develop and promote viable mitigations. In all cases, potential savings must then be measured against construction and land use considerations, on an ongoing basis, in all parts of the nation.

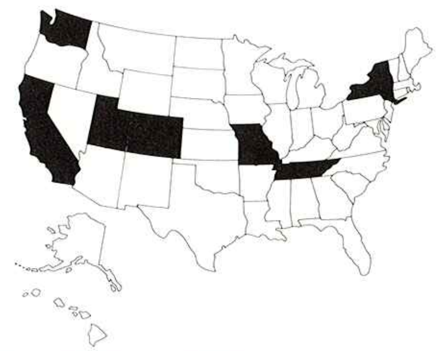
There are growing indications that more stringent building codes and land use requirements either may not be sufficient or fail to offer the ideal solution. It is doubtful if the technical capabilities of 55,000 separate jurisdictions are adequate to administer such comprehensive programs, regardless of their beneficial impact. At the very least, more trained people are required to develop and test the mitigations, draft the codes and participate in their enforcement. Perhaps provision of incentives for individual and local action might offer a more effective answer than enactment of more regulations.

The challenge is enormous, but the stakes are high. Billions of dollars and thousands of lives can be saved over the next decades by mitigating the losses caused by any one or a combination of these natural hazards.

EARTHQUAKE



STATES WHICH PROJECTIONS SHOW HAVE EXPERIENCED 95% OF NATIONS'S EARTHQUAKE INTENSITIES



Far more areas of the nation have experienced severe earthquake damage than is generally recognized. During the past 200 to 400 years of recorded earthquake history, only 25 of the 50 states have been virtually quake free.

Based on today's exposure and past history, California would account for over 65 percent of the nation's earthquake damage to buildings. Another nearly 30 percent would occur in six states seldom linked with the hazard: Colorado, New York, Missouri, Tennessee, Utah and Washington. In fact, over the span of reported history, there have been severe quake intensities registered in each of these seven states, as well as in Arkansas, Illinois, South Carolina and New England.

The first step in the Wiggins Study was to develop a hazard map of shake intensity by geographic location, based upon reported earthquake history. The nation's building inventory was next superimposed onto the map and broken down by building type, then related to potential vulnerability for the purpose of computing the probable losses.

New Approaches Required

Even if the reported pattern of earthquake frequency and/or intensity remains constant, more and more dollars will be required to replace or repair buildings destroyed or damaged by earthquakes unless new approaches which mitigate such destruction are identified and implemented. This is because the rising value of real estate, even after being discounted for inflation; the growing ratio of buildings to people in earthquake susceptible areas; and the continuing population movement to these regions all tend to boost the loss probability at an ever-increasing rate.

If history continues to repeat itself, conservative models indicate the potential annualized cost of replacing and repairing buildings hit by earthquakes will increase almost 25 percent in constant dollars between 1970 and 1985. It will then rise another approximately 45 percent between 1985 and the year 2000. Other computer models were developed to estimate possible loss reductions if any of several potential approaches to minimizing building damage from earthquakes were taken.

An approximately 15 percent reduction in new construction losses and 5 percent lowering of overall building losses could be realized annually by the year 2000, if the new NSF/NBS/ATC code was invoked throughout the nation, beginning in 1980. This code, recently developed for the Bureau of Standards by the Applied Technology Council of the Structural Engineers Association of California under a National Science Foundation grant, would require new buildings to be approximately twice as earthquake resistant as they are today.

Another approach suggests annualized new construction losses could be cut up to 12 percent and overall structural building losses reduced approximately 5 percent by 2000, if the existing 1973 Uniform Building Code, published by the International Conference of Building Officials, was required across the country after 1980. These savings could be approximately doubled by doubling the code requirements for damage resistance.

Loss Reductions Possible

A third model demonstrates that if the nation can replace existing structures 10 percent faster than it is currently doing, as well as require all new construction to adhere to the 1973 Code, beginning in 1980, losses will drop 8 to 10 percent annually by the year 2000.

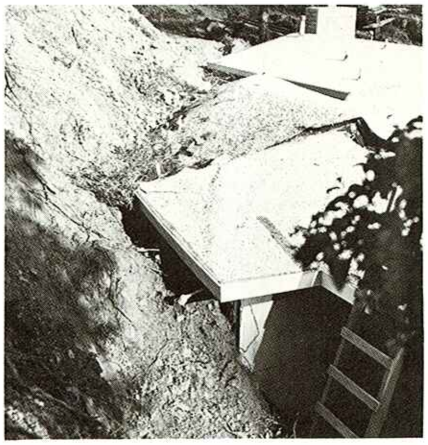
A great deal of money has been allocated to research aimed at early detection of impending earthquakes, as well as potential methods for preventing or delaying them or diminishing their intensity. Unfortunately, thus far none have met with significant success. Surprisingly, according to one model, if current experiments aimed at eliminating major quakes by breaking them into a series of smaller ones were successful and the technology implemented, the annualized cost of building damage would actually increase nearly 45 percent.

Impact More Dramatic

When applied to a computer scenario based upon an actual event, the impact of these findings is even more dramatic. One scenario is targeted at determining what damage to buildings caused by the 1906 San Francisco Earthquake would cost, in constant dollars, if it reoccurred in 1970, 1980, 1990 and 2000. The quake, which was measured at over 8 on the Richter Scale, destroyed buildings with costs translated into 1978 dollars of almost $170 million and took 700 lives. The fire which ensued caused another $3.5 billion in damage. The model indicates that should the quake reoccur in 1980, it would cause $24 billion in building damage and about 5,000 deaths and 700,000 injuries. Much of this increase is due to the larger number and value of buildings, as well as population growth since 1906. Dollar losses are limited, however, to shake damage and do not take into account the possibility of later fire damage or destruction of any kind to infrastructure. Using similarly conservative figures, by 1990, the costs would mount to $30 billion and in 2000, they would reach $36 billion. Lost lives would increase to over 5,000.

It appears that taking any one or combination of the steps cited earlier could bring these losses down dramatically.

LANDSLIDE



PROJECTED ANNUALIZED LOSSES FROM LANDSLIDE BY STATE UNDER 1980 CONDITIONS
(1978 dollars in millions)

Who cares whether most landslide damage is the result of "An Act of God" or is largely preventable by "Acts of Man"? Probably not many of us. But this is one of several unresolved questions which could significantly affect the expenditure of billions of dollars and the lives of many people over the next 22 years. Here are four reasons why:

(1) Although homes, condominiums and small businesses usually represent the largest single investment made in an average family's lifetime, landslide damage to them is no longer covered by domestic insurance carriers. In fact, landslide damage has been specifically excluded from all but the very largest, multi-million dollar corporate policies. Slide victims generally don't qualify for Federal or state aid, either, unless a major disaster is proclaimed.

(2) Landslides annually cause more measureable damage in more states than any other natural hazard except expansive soil, riverine flood and tornado.

(3) There's widespread agreement among experts that most landslides could be prevented or slide damage avoided if adequate land use and construction requirements were added to building codes; these codes were effectively enforced; and early detection methods, utilizing existing technology, were employed. However, until a city has been hard hit, as Los Angeles was two decades ago, this strengthening of codes and enforcement simply does not happen.

(4) Unless this pattern is altered, landslide damage to buildings will soar over 130 percent between 1970 and 2000. This is primarily because scarcity of available land in urban centers and development pressures are causing more and more homes to be built in areas susceptible to slides; population movement to more hazardous sections of the country is increasing; and the value of land and buildings is rapidly rising.

Record Keeping Inaccurate

Record keeping in many areas of the country is acknowledged to be woefully inadequate. An intensive review of all available historic data reveals that virtually all states suffer some degree of landslide damage. Predictably, over 45 percent of all slide damage to buildings occurs in six heavily populated states: California heads the list, accounting for over 15 percent of the damage. The others are Pennsylvania, New York, Ohio, Maryland and Illinois. The remaining 55 percent is fairly evenly divided among the rest of the states and the District of Columbia.

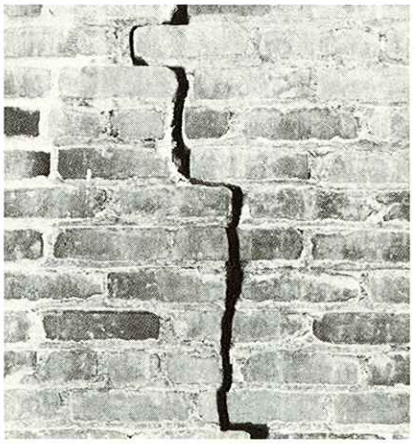
Averaged over 10 years to take into account the fact that some regions have severe slides every year and others every two to five years, the nation's building losses from landslide during a typical year, under 1970 conditions, total 360 million 1978 dollars. This represents about 35 percent of the United States Geological Survey's estimate of 1977 slide dollar losses from all structures, including roads and bridges, which totalled approximately $1 billion.

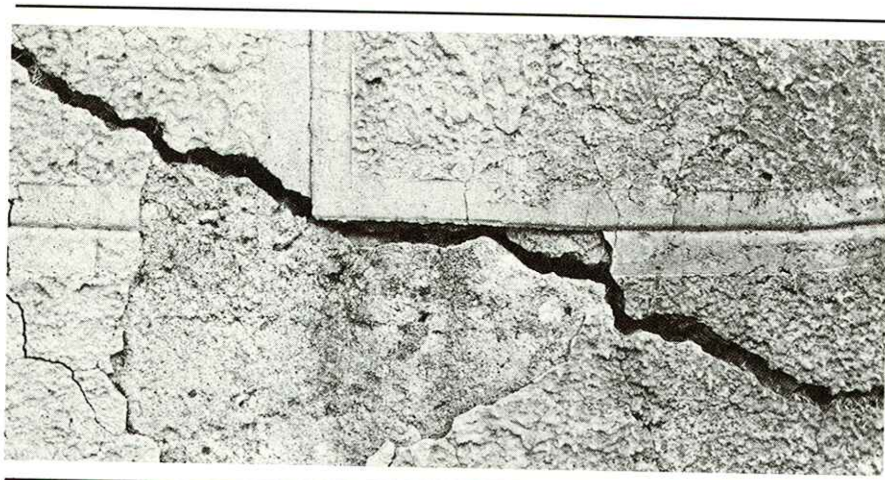
Appropriate Steps Needed

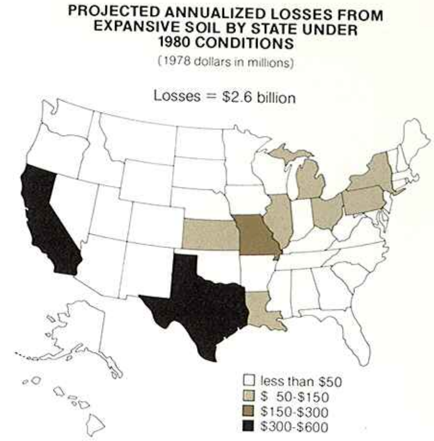
Unless appropriate broad-scale steps are taken to prevent slides or minimize damage, annual building losses from landslide will increase to at least 480 million 1978 dollars by 1980; $650 million by 1990; and $830 million by 2000. Based on USGS figures, total primary losses might well be three times higher.

Computer modeling reveals that more than a quarter of a billion dollars could be saved every year by the year 2000, just in the cost of replacing or repairing buildings hit by slides, if Chapter 70 of the Uniform Building Code were to be applied to all new construction across the nation, beginning in 1980. Indications are that at least 90 percent of all new buildings, therefore 30 percent of all existing ones, could be saved by taking this approach.

EXPANSIVE SOIL





Few people have ever heard of expansive soil. Even fewer realize the magnitude of the damage it causes. In most cases, it takes a professional soils engineer to confirm its existence and evaluate its probable behavior.

Yet, over one-fifth of the nation's families live on such soil and no state is free of significant amounts of it. What is frequently referred to as "The Hidden Disaster" accounts for over $1.9 billion in building losses during a typical year, under 1970 conditions, based upon 10-year averages.

In fact, expansive soil ties with hurricane wind/storm surge for second place among America's most destructive natural hazards, in terms of dollar loss to buildings. Its destructive impact is currently surpassed only by that of riverine flood.

Soil Expands 15 Times

Typically, the clay within expansive soil can expand up to 15 times its original dimensions when wet, shrinks when drying, then creates forces of up to 30,000 pounds per square foot when it expands again. Such forces will shatter or break most building materials.

The hazard is most dangerous to buildings in states which have clearly delineated wet and dry seasons. California and Texas collectively account for about 35 percent of the nation's expansive soil damage to buildings, but fully half of the states annually suffer building damage in excess of 20 million 1978 dollars from the hazard.

Actually, most expansive soil estimates are probably low because buildings which slowly deteriorate over a period of many years from the effects of the hazard usually aren't numbered among its victims.

Partially in recognition of this situation, since 1960 the Department of Housing and Urban Development often has required far more stringent construction controls on new homes covered by FHA loans. In spite of the policy, however, unless further steps are taken, typical-year building losses from expansive soil will increase to over 4.5 billion in constant dollars by the year 2000.

The primary reasons a computerized model predicts this are the rising value of buildings; current building practices trending toward broader use of slab foundations; and the accelerated rate of population growth into parts of the nation where expansive soil is more prevalent.

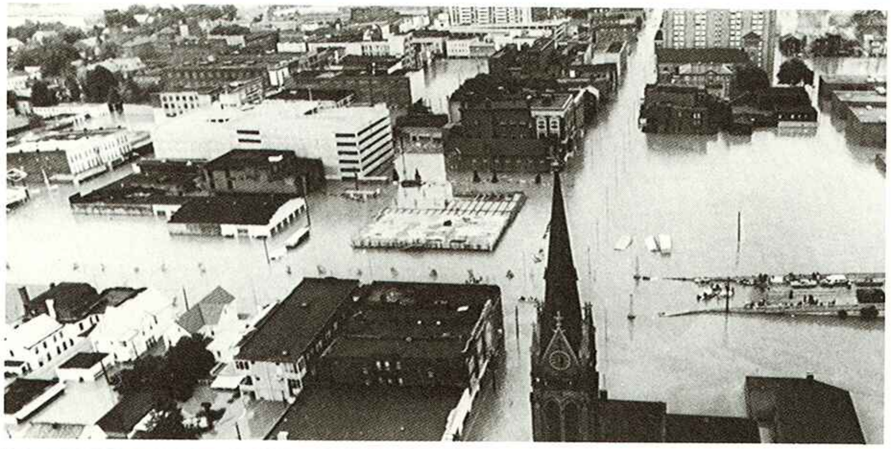
If a nation-wide policy requiring only pre-construction soil moisture, soil density and site drainage control was initiated in 1980, by the year 2000, new construction losses from expansive soil could be reduced at least 30 percent and overall building losses, over 10 percent.

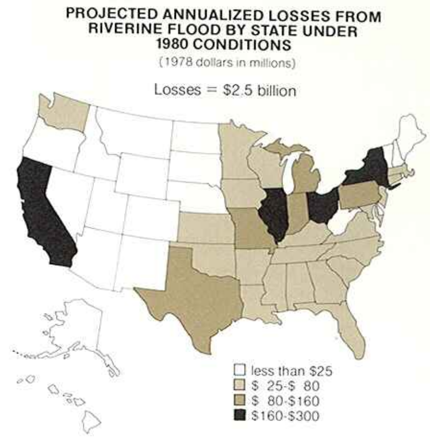
$1.5 Billion Savings

A total of $1.5 billion could be saved annually beginning in year 2000 if either soil stabilization prior to construction or stronger foundations became standard across the nation, starting in 1980. This could reduce yearly new construction losses up to 85 percent and overall building losses from expansive soils approximatly 35 percent by the year 2000.

Indications are that if soil stabilization and improved foundations were universally employed in combination, losses from what would otherwise continue to be one of our nation's two most devastating hazards could be brought down to easily manageable proportions.

RIVERINE FLOOD





An unfortunate by-product of the fact that man has traditionally chosen to settle by rivers is the enormous toll taken each year by riverine flood: On the basis of annualized averages, overflowing waterways destroy or damage approximately 410,000 buildings across the nation in a typical year, under 1970 conditions, with an aggregate cost of over 3 billion 1978 dollars.

Riverine flood is America's most devastating natural hazard, historically wreaking more havoc in more states than any other. Although nine widely separated states suffer over 50 percent of the building damage from such floods, 35 experience more than $20 million in building losses during an average year.

Losses Will Drop

Government's concern over the magnitude of this problem has triggered stepped-up flood loss reduction efforts in recent years to a point where it appears the year-to-year surge in the cost of buildings damaged by flood might be at least temporarily reversed. Computer models indicate the earlier cited losses will drop about 2 percent each year because of this between 1970 and 1980. But, unless the current rate of flood loss reduction efforts is accelerated, losses will start climbing again as the turn of the century approaches, increasing almost 15 percent between 1990 and 2000.

Many feel, however, that the projected drop, followed by an approximately 15 percent rise, will prove overly optimistic if the current rate of urban growth on the flood plains continues unabated.

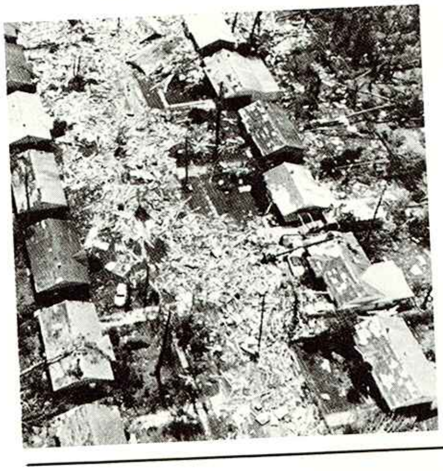
It was impossible to factor this into the computer model when projecting losses through 2000 or predicting potential mitigation savings, since the duration and dimensions of the current trends cannot be accurately assessed.

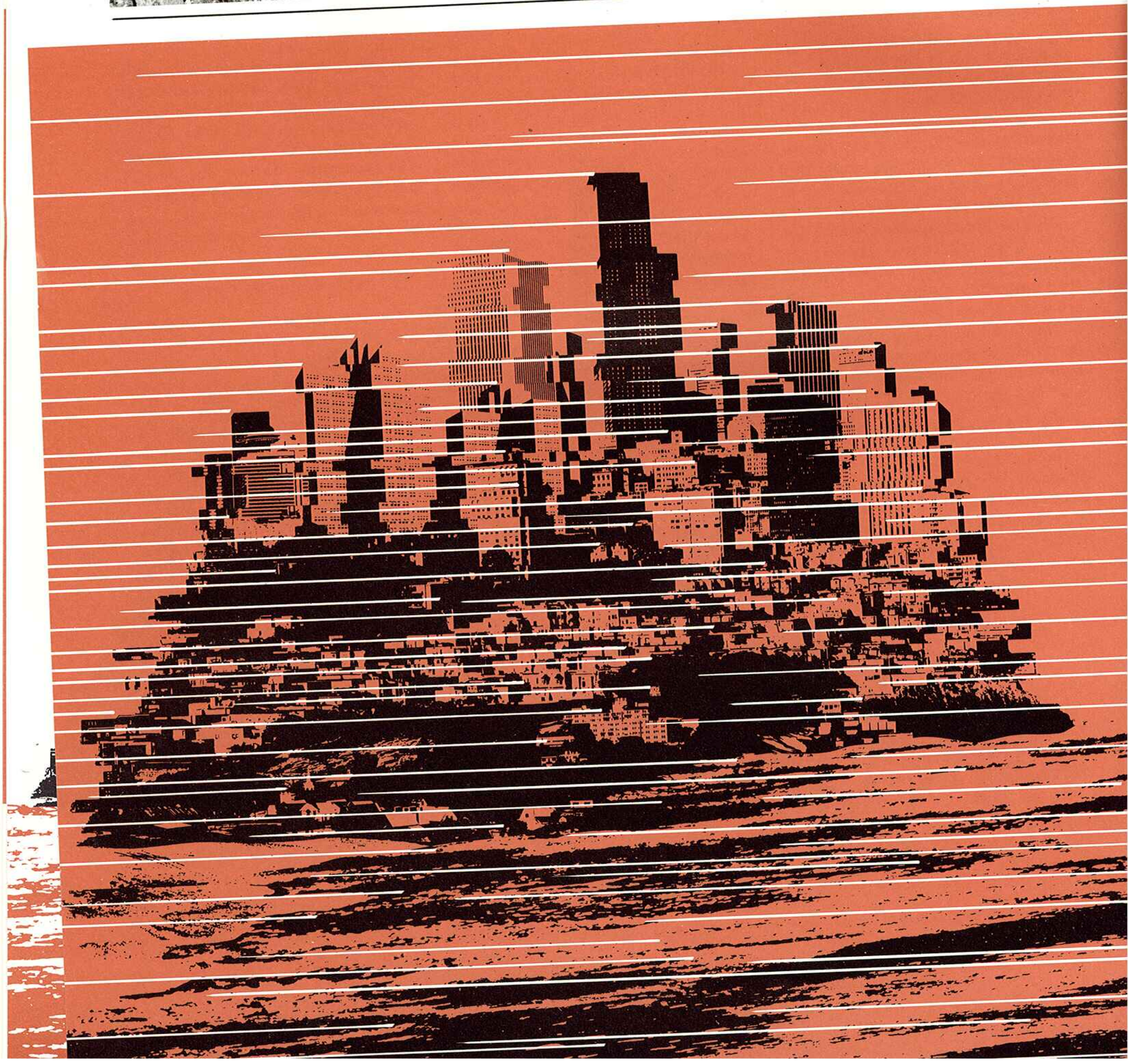
Without taking this factor into consideration, the model reveals that if 25 typical cities per year required more rigid building siting and construction control, beginning in 1980, it would be possible to save $850 million annually by the year 2000. The 20 percent loss reduction would partially result from zero occupancy growth on the 50-year flood plain during this 20-year period. The remainder of the saving would largely be derived from the protection provided by a 100 percent increase over the present rate of dam, levee and flood wall construction.

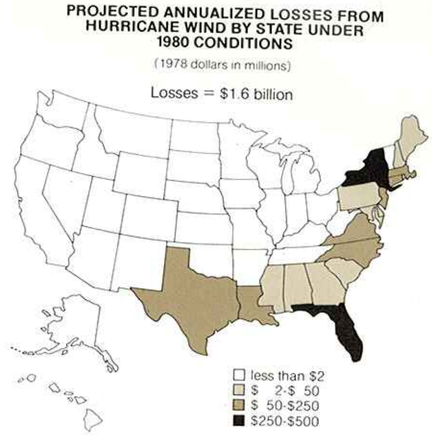
$2.5 Billion Reduction

Another mitigation envisions the same level of protective public works activity as we have today; 25 cities per year, beginning in 1980, adding building siting and construction controls; and a requirement that all new buildings on the 50-year flood plain be elevated by four feet. This, the computer predicts, would reduce annual building losses from flood down to about $2.5 billion by 2000, a reduction of $500 million a year. Only 294,000 buildings a year would be destroyed or damaged by floods after 2000, in contrast to 410,000 today, and those which were affected would probably be damaged less.

HURRICANE WIND/STORM SURGE







Unless something is done to prevent it, hurricane damage to buildings in 21 states will probably increase about 160 percent between 1970 and the year 2000.

When viewed over a typical 20-year period, the combination of storm surge and hurricane wind accounts for annual building losses of almost 2 billion 1978 dollars, under 1970 conditions. Computer models indicate that by the year 2000, hurricane wind and storm surge losses will increase over $3 billion to approximately 5 billion annually in constant dollars, easily exceeding the building damage caused by any other natural hazard.

Causes Of Increase

This alarming increase will be largely due to rapidly accelerating coastal development, population movement to more hazardous areas and mounting building and replacement costs. Too little has occurred since the recent passage of the Coastal Zone Management Act to document any definitive pattern of improvement which could be programmed into the computer models.

Today, almost 40 percent of all hurricane damage comes from storm surge, which strikes hardest at such low-lying coastal states as Florida, Mississippi and Louisiana. Hurricane winds account for the other 60 percent. Although the winds may not be accompanied by storm surge in the District of Columbia, Pennsylvania, Vermont and New Hampshire, they *are* in most hurricane-sensitive states. Damage from the combined impact of wind and sea is greatest in Florida, New York, Louisiana, Massachusetts and Texas. Overall, 16 states currently suffer $20 million a year or more in building losses from hurricane.

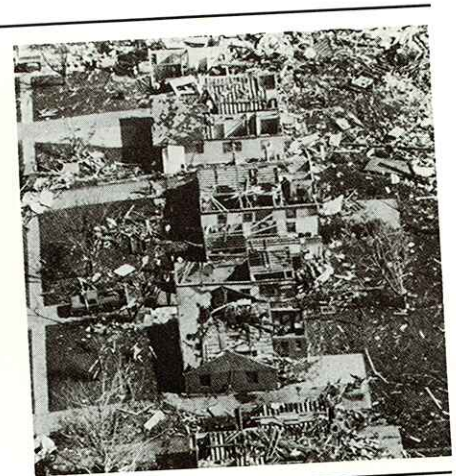
The basis of all damage estimates from hurricane winds utilized in the Wiggins studies, were provided by a panel of distinguished wind experts. If all new buildings in hurricane-susceptible areas were required to be 50 percent more wind resistant and four additional counties per year were protected by sea walls for the 100 year event beginning in 1980, a computer model reveals that by 2000 it would be possible to save approximately 2 billion 1978 dollars and many lives a year. Such wide-scale construction of sea walls, of course, is highly unlikely. In addition, there are those who feel that if such a plan was instituted, it could conceivably create a false sense of security, causing construction to accelerate even faster in vulnerable areas. Should this occur, it could sow the seeds for a more catastrophic event when the "once-every-200-year" hurricane struck.

$1.5 Billion Reduction

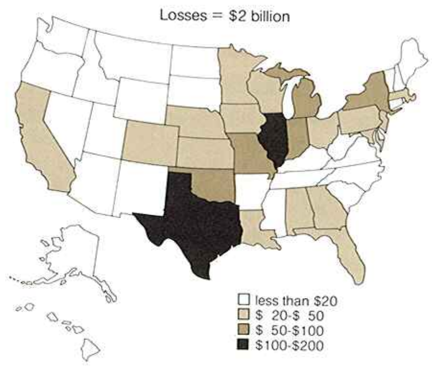
A second mitigation forecasts annual reduction of more than 1.5 billion in constant dollars, or 35 percent a year, after the year 2000. It would require all new buildings to be 50 percent more wind resistant and that all of them in storm surge areas be elevated by four feet, beginning in 1980.

By eliminating basements in all new coastal buildings and strengthening their wind resistance by 50 percent, starting in 1980, annual savings of 1 billion 1978 dollars, or 20 percent, could be realized after the year 2000, according to a third mitigation.

TORNADO



PROJECTED ANNUALIZED LOSSES FROM TORNADO BY STATE UNDER 1980 CONDITIONS
(1978 dollars in millions)



Although Illinois would suffer the greatest dollar damage, because it is the most densely populated of the nation's tornado-prone states, 21 different states sustain tornado losses to buildings in excess of $20 million 1978 dollars during a typical year.

Accurate damage assessments are unavailable in many sections of the country because destruction to areas outside of the center of a tornado's path is sometimes ignored. However, of all the natural hazards, it is the biggest killer on an annualized basis.

Wind Patterns Reviewed

Computer projections reveal that nation-wide tornado damage to buildings during a typical year, under 1970 conditions, averages at least 1.5 billion 1978 dollars. This estimate stems from a comprehensive review of tornado strikes by frequency and intensity over many years and projections of likely damage from them.

Because of rising building value and population growth in the Central States' "Tornado Alley," twister damage to buildings across the nation will probably increase more than 130 percent between 1970 and the year 2000, hitting 3.5 billion 1978 dollars by 2000. Many regard the estimate as low, but there is no way to be certain because of the current state of the art.

If the 1973 Uniform Building Code were strengthened 50 percent in all categories pertaining to wind resistance and was employed nationally beginning in 1980, a computer model indicates that, by the year 2000, tornado losses to new construction could be reduced about 45 percent. Overall building losses would drop 15 percent.

Chicago Scenario Created

Turning to a computerized scenario: If a 4 Fujita Magnitude tornado, with winds up to 250 mph, cutting a swath of 29 square miles, hit certain sections of the Greater Chicago area in the year 2000, it could cause building damage of approximately $6 billion and almost 2,000 deaths. The level of devastation would, naturally, vary, depending upon the area of the city hit. This is not an unthinkable scenario in that two such tornadoes *have* hit the Chicago area since 1934. All told, 29 tornadoes of varying intensities have struck the Windy City in this 44-year period.

A totally accurate forecast of potential damage to Chicago's Loop is not possible at this time. At least one school of thought, as yet unproven, holds that the impact of a high velocity tornado striking downtown might conceivably be lessened by heat welling up between tall buildings during the tornado season deflecting some of the winds upward. Others theorize that skyscrapers might shield one another. Regardless of whether or not this is the case, an "average" scenario reveals that if all buildings constructed in Chicago after 1980 were 50 percent more tornado-resistant, annual losses from such a 4 Fujita tornado after 2000 could be reduced almost 15 percent.

ACKNOWLEDGEMENTS

List Of Acknowledgements For The Report Entitled: National Losses And Mitigation Effects For Air, Earth And Waterborne Natural Hazards

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Engineering Geology Consultants, Inc.:

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The dedication and long hours spent by all personnel involved in the program are deeply appreciated.

Support for this effort was provided by Dr. Charles C. Thiel, Dr. G. Patrick Johnson and Dr. Michael P. Gaus of the National Science Foundation.

Special thanks are due Mr. D. Earl Jones, Jr., Chairman of the ASCE Oversight Committee, for his many constructive comments and suggestions made throughout these studies.

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Hart, Gary C., *Natural Hazard: Tornado, Hurricane, Severe Wind,* J. H. Wiggins Company Report prepared for the National Science Foundation under Grant #ERP-75-09998 (December 1976) and #AEN-74-23993.

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