Mississippi Insurance Department

Comprehensive Hurricane Damage Mitigation Program

Cost and Benefit Study

Final Version

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Table of Contents

List of Figures

List of Tables

Executive Summary

Mississippi passed a law in 2007 as a first step toward establishing a comprehensive public policy program promoting hurricane wind loss mitigation (Program) for homes and businesses in its six coastal counties. An early and significant step in developing support for mitigation is a Study, required by the law, examining several aspects of the proposed Program:

- What are the most beneficial construction designs and features mitigating hurricane losses?
- What is the current state of the building stock in coastal Mississippi?
- How significant are the potential benefits, in the form of reduced expected hurricane losses and therefore reduced hazard insurance premiums, of better construction features – both in isolation and in combination?
- What are the likely costs of retrofitting “unmitigated” structures in the current building stock with better construction features, and how do we identify actions containing the best bang for the buck (ratio of benefits to costs)?
- How should Mississippi put this technical information into action by establishing a strong, comprehensive public administration function – including public outreach - for the Program?

After a competitive bidding process, the Mississippi Insurance Department (MID) engaged AIR Worldwide Corporation in April 2009 to perform an initial Study. AIR performed the required analysis over the succeeding four months, and delivered a draft report on August 21, 2009. MID convened consultations among various stakeholders, AIR, and itself over the remainder of 2009, resulting in many suggestions for additional analysis and explanations of AIR’s conclusions to be included in a next draft. This version of the report is the result.

Feature Identification

AIR began by considering our existing expertise on the subject, developed through over twenty years of experience in simulating hurricanes and their financial impacts on insurable structures and related assets. Employing meteorologists, statisticians, civil and structural engineers, construction managers, actuaries, software developers, and other professionals, our complex architecture and embedded scientific expertise results in a hurricane model which simulates thousands of years of storm activity against any set of properties with building characteristics described to the model and software. The model considers the hurricane parameters, develops a wind footprint for each simulated event, and applies each event and its wind speed and duration to every geographic location (and its associated building characteristics) entered into the software. Engineering calculations based on those wind loads then determine the damage ratio to each location, and actuarial calculations based on the damage ratio and the stated replacement value of the property are used to translate the raw damage estimates into insurable losses. The engineering calculations are highly tuned to the construction and mitigation features applicable to each individual property.

AIR also incorporated the views of local and regional building and engineering experts by inviting peer reviews of the model by professors from Louisiana State University (LSU) and the University of Mississippi, and other outside reviewers. Adjustments were made to the individual risk model to account for local conditions.

We identified the following features as significantly mitigating residential and low-rise commercial hurricane wind losses. Feature categories studied by AIR are listed from most vulnerable (“unmitigated”) to least vulnerable.

Roof Geometry: Gable unbraced > Gable with ends braced > Hip, mansard, or pyramid

Roof Cover+Attachments: Non wind-rated asphalt shingles or tiles > wind-rated (e.g. Florida Building Code equivalent) shingles or standing-seam metal > Reinforced concrete

Roof Deck+Attachments: 6d nails at 6”/12” > 8d nails at 6”/12” > 8d nails at 6”/6” > Reinforced concrete deck

Roof Anchorage: Nails or screws > Clips > Hurricane ties (e.g. single or double wraps)

Window Protection: None > Non-engineered shutters > Engineered shutters (or impact resistant glass as a functional equivalent)

Secondary Water Protection: None > Protection present

Pool enclosures increase vulnerability, as do **unreinforced garage doors**. **Reinforced garage doors**, by contrast, enable the building to perform similarly to one without garage doors.

Interestingly, actual loss data shows that the **year of construction** also significantly influences vulnerability, in ways which cannot be solely explained by mitigation features and building code requirements. A separate year-built factor that applies on the top of mitigation features is used to capture this residual year-built effect.

For commercial mid- and high-rise structures, additional influential features are:

Roof Deck: Wood deck > Metal deck with insulation > Metal deck with concrete > Reinforced concrete slab

Wall Siding: EIFS > other siding

Glass Type: Annealed > Tempered > Laminated > Impact-resistant

Glass Percent: More than 60% > 20% to 60% > 5% to 20% > less than 5%

However, given the fundamentally different roof construction, roof geometry and roof anchorage are not generally applicable to these structure types.

Building Stock Distribution

Understanding the state of the current building stock is very important for several reasons; among these is that it influences the determination of the “base” or reference structure for the calculation of insurance benefits in the form of mitigation credits or debits relative to that structure. AIR has industry-wide databases which do not contain detail on the presence of each important mitigation feature, so we contracted with LSU to perform an original neighborhood-level drive-by survey of many construction features in the six-county area and collect the results for analysis. We summarize the distribution of various feature categories from this survey. We also analyzed a limited amount of data from the insured property files of the Mississippi Windstorm Underwriting Association (MWUA) and from previous inspections performed by the Mississippi Development Authority (MDA). The results contained in these data sets influenced our choices of reference structures for the benefits and costs analyses.

Insurance Benefits Analysis

For this Study, 10,000 years of simulated hurricanes were applied to a property data set representing many geographic locations spread around the six-county area. No considerations were made for storm surge (which is not covered in residential policies) or demand surge (sudden and temporary repair cost increases after hurricanes). The results were stated as “gross losses” to an insurance policy with an assumed 2% hurricane deductible.

The data set was “what-if” scenario-tested at each location, with every combination of construction designs and features identified as beneficial, to determine the indicated insurance benefits, measured by reductions in the “average annual losses” (AALs, defined as expected hurricane wind losses per year as a result of the 10,000-year simulation) to each property. The AALs were converted to “loss costs” (defined as AAL per $1,000 of exposure), and the relative loss costs among each feature combination were analyzed and put into tables of insurance benefits relative to several reference structures.

General findings regarding features which offer benefits in the form of lower AALs are listed below.

- Homes built to the International Residential Code (IRC) 2003 code should benefit from significant reductions in average losses (depending upon the design wind speed region) over typical pre-1995 homes (assuming they are not retrofitted to IRC code requirements). Homes built after 1994 but not to the new code benefit as well, but by a smaller amount.
- Hip roofs offer significant benefits over gable unbraced roofs. Bracing a gable roof offers some benefits over an unbraced roof.
- A well-mitigated roof system can result in significant benefits versus an unmitigated basic roof system, and these benefits are further increased when engineered shutters are present on the structure.

- Engineered shutters, or alternatively impact resistant glass, alone offer rather significant benefits, which are dependent on the roof geometry. The benefits of engineered shutters are larger for homes built to IRC 2003. Non engineered shutters also offer some benefits, but generally lesser than those for engineered shutters.
- For construction to IRC 2003, benefits depend on the “wind speed zone” (defined based on distance to coast) of the property. For these properties, the roof system is considered as part of the loss reduction based on year built, except that using additional secondary water protection can offer a small additional benefit which also depends upon the wind speed zone.
- Pool enclosures are a significant contributor to losses, rather than a loss mitigation feature.
- Unreinforced garage doors can also increase losses because they offer a potential weak point in the building envelope.
- For mid- and high-rise buildings, opening protection (e.g., impact resistant glass) and metal roof decks with secondary water protection or reinforced concrete roof decks can reduce the losses significantly.

It is vital to note, however, that the magnitude of AAL benefits in each case does not translate directly and proportionately to an equivalent savings on overall insurance premiums. This is largely because premiums depend on loss costs for all covered perils, not just hurricane wind. Further, even the hurricane portion of the premium, though driven by the AAL, must reflect other economic factors – such as underwriting expenses and costs of reinsurance capital – which are not reduced proportionately with the average annual loss. The total, so-called “indivisible” premiums for a residential or commercial property policy are the product of numerous inputs and factors; hurricane wind AALs are just one such input.

In the ‘Results of Insurance Benefits Analysis’ section of the Study, we illustrate potential premium savings for a hypothetical homeowners policy by creating a fairly complex - but typical - rating formula for a hypothetical insurer and attaching the mitigation adjustment algorithm to that formula. Components of the hypothetical rating formula were drawn from publicly available rate filing information from some insurers in Mississippi to ensure that the treatments and assumptions we used were reasonable. The results, though instructive, are not summarized here because they are dependent on the assumptions used in their creation; generalization and communication of these results without the underlying detail could be misleading.

It is important to recognize that many features, such as roof systems, roof shape, and opening protections work together to reduce losses and a simple actuarial approach of “multiplicative” or “additive” credits in sequence for each feature is not advisable.

Feature Costs

Costs, like benefits, are very difficult to analyze piecemeal, since it is often efficient to make multiple retrofits in a single construction project and depend on the “starting point” or level of existing loss mitigation. We analyzed the costs to retrofit a residential reference "unmitigated" building with all feasible combinations of beneficial features. Some typical situations are described below for a reference building of $150,000 in replacement value.

- Upgrading the roof system (cover, deck, anchorage), without changing its geometry, typically costs between $5,000 and $9,000 (4-8% of structure value) depending on the level of upgrades.
- Installing secondary water protection is expensive on its own, on the order of $6,000, but far less expensive when done in conjunction with a roof system upgrade, adding only an additional $1,000 or so.
- Shutter installation operates mostly independently from roof upgrades and the cost is estimated at around $4,000 for the reference building.

The best way to analyze a specific retrofit scenario or "mitigation package" in terms of its net benefits over costs, or "bang for the buck," is to first find the insurance benefits and costs in the tables. The second step is to input the insurance benefits into a rating algorithm in order to estimate their impact on an annual premium dollar basis. Finally, the premium savings are compared to the installation costs to determine the "payback period" or number of years to return the homeowner's investment in the form of lower premiums.

While it is impossible to analyze every conceivable scenario in this way, AIR has offered a few common packages (such as a roof system upgrade) and a sample payback analysis using this approach.

Launching a Public Program Encouraging Mitigation

We hope MID can use the quantitative data and discussion in this Study to help launch a successful Program. Such a program will have several key elements:

- Proper consideration of impact on existing insurance products and rates;
- Good administrative structure and governance;
- Effective consumer and business outreach;
- Robust and fraud-resistant inspection program;
- Positioning to attract partners and additional funding sources.

First, implementing the Program by making changes to property insurance rules and rates is complicated by the fact that insurers are currently rating for some features but not others, using a variety of reference structures underlying their base rates, and have limited ability to make wholesale changes in a short timeframe due to statutory and regulatory requirements for certain credits as well as information technology limitations. Compounding all of these technical challenges are the worries about the effect on existing policyholders and consumer complaints, as well as competitive position over time.

To preserve and continue the actuarial soundness of rates, insurers and regulators must consider some or all of the following actions:

- Adjusting base rates to reflect a reference structure which is consistent with the basis of any mitigation credits or debits;
- Adjusting or eliminating overlapping credits/debits for the same features;
- Separating base premiums by peril, so that mitigation plans can be applied to only the hurricane portion of the premium;
- Applying mitigation factors selectively by coverage and line of business;
- Adopting “swing limits” on changes in annual premium, adjusted for exposure and coverage changes, through a transition rating plan for renewals;
- Potentially tempering the amount of credits and debits, or phasing in such factors over multiple years, if a robust transition plan is not applied at the individual policy level.

Second, the Program must be housed in the proper state agency(ies) and with proper controls and oversight. In particular, there should be ample public access to the Program and the public sector should position itself to partner with other state and federal agencies as well as non-profit and private sector organizations to leverage its resources.

Third, massive public outreach through a variety of channels is important. It is easy to underestimate the needs in this regard. Brochures, digital portals, and pilot programs are all important, and the messaging content of those items must be oriented toward answering key questions from a perhaps-skeptical public and providing comprehensive views of the many benefits of wind loss mitigation – not just lower insurance premiums, but improved structures, safer lives and property, and faster recovery from disasters. Outreach is one of the tasks in which leverage and partnership with outside stakeholders – contractors, home improvement retailers, realtors, insurance agents, lenders, and public and emergency management officials – is most important.

Finally, the Program should be positioned to attract funding for grants and prepared to fairly distribute them in a fraud-minimizing fashion. Several sources of funds from existing programs, state and federal, should be investigated, and certain key mitigation actions prioritized in the grant program. A fraud-resistant and effective inspection regime contains perhaps more execution risk than most of the public administration tasks. Specific indicators of poor or fraudulent inspections should be deployed, uniform inspection forms and standard training for inspectors, and other critical pieces of infrastructure should be developed and managed to ensure wise expenditure of taxpayer or private dollars.

Reliances, Limitations, and Questions

The Reliances and Limitations within the Introduction section of this Study should be read in detail by all readers of the Study. The Study is intended for the use of MID. MID should contact

AIR directly regarding any questions or comments about the Study. The AIR professionals and consultants who produced this Study are available for limited time periods to answer questions.

AIR is pleased to provide this Study to MID and appreciates its engagement of and cooperation with our team.

Introduction

AIR Worldwide Corporation (AIR) is pleased to present this study (Study) supporting the rationale for and establishment of a Comprehensive Hurricane Damage Mitigation Program (Program) in the six coastal counties of Mississippi.

Background

The Enabling Law

During the 2007 Mississippi legislative session, state lawmakers enacted §83-2-191, which established the Comprehensive Hurricane Damage Mitigation Program and directed the Mississippi Department of Insurance (MID) to implement and administer it, subject to funds availability, with the directive that the state is not obligated to fund it. The law also:

- Mandates a cost-benefit Study on wind hazard mitigation construction measures for residential and commercial structures;
- Outlines parameters for wind certification and hurricane mitigation inspections;
- Encourages financial grants to retrofit properties;
- Mandates a public education program to raise the awareness of the advantages of reinforcing structures to make them more resilient;
- Establishes an advisory council consisting of representatives from various stakeholders;
- Provides MID authority to establish rules and regulations.

The Program was created to help Mississippi property owners (both residential and commercial) to identify how to strengthen their homes against hurricanes and to reduce hurricane damage exposure. To accomplish these goals, the Program offers wind mitigation inspections and encourages the retrofitting of the property with the owner bearing these costs. The law also requires that inspectors used through the Program must undergo drug testing, background checks, and receive specific training on hurricane mitigation techniques. MID is attempting to secure government funding to provide grants for retrofit purposes.

The Request for Proposals and AIR's Response and Role

The MID issued a Request for Proposals (RFP #091601) on January 16, 2009 to "establish the Program." The expectations for the responses were described in the General Statement as including:

- Establishment of the most appropriate wind hazard mitigation construction measures for new construction and retrofitting of existing construction for both residential and commercial facilities within the wind-borne debris regions of Mississippi as defined by the International Building Code.

- Performance of modeling on a variety of residential and commercial designs, so that a broad enough representative spectrum of data can be obtained.
- Preparation of a report establishing tables reflecting actuarially appropriate levels of wind insurance discounts for each mitigation construction technique or combination of techniques.
- Development and collection of data that will enhance the Program, such as studies to reflect property value increases for retrofitting or building to the established wind hazard mitigation construction techniques and cost comparison data collected to establish the value of the Program against the investment required to include the mitigation measures.
- A Program Scope of Work that defines all necessary tasks for accomplishing the goals and requirements of the Mississippi Hurricane Damage Mitigation Program.

AIR responded with a Proposal on February 12, 2009, indicating our ability and willingness to address the items above. The Scope of the model-driven analysis of costs and benefits is as follows[1].

- **Geographic**: limited to the six defined "coastal" counties of Mississippi (Jackson, Harrison, Hancock, Pearl River, Stone, George);
- **Occupancy**: both residential and commercial structures (It is efficient and practical to place more emphasis on residential structures, as there is a greater number and variability of mitigation features applicable to retrofitting opportunities, and a general separation in building codes for structures constructed before 2007 versus those constructed afterward. However, commercial structures are also analyzed.);
- **Perils**: hurricane wind damage only, no consideration of storm surge losses.

The general work plan, as we outlined in our Proposal, as follows:

1. Research and identification of beneficial hurricane wind mitigation features (which are somewhat different for residential and commercial structures);
2. Assembly of building stock and claims validation data for modeling, including collection of original data regarding the building stock in coastal Mississippi;
3. Estimation of benefits, in the form of loss cost relativities for various construction feature combinations for residential and commercial structures;
4. Assembly of cost data for features, and matching with modeled benefits (defined as reduced insurance losses as well as property value effects);
5. Program Scope of Work that outlines tasks AIR Worldwide can contribute for successful implementation of the Mississippi Hurricane Damage Mitigation Program.

[1] It is important to note here that AIR defines, for purposes of analysis, "benefits" to mean changes in *modeled expected annual insurable hurricane losses* resulting from various combinations of construction features, relative to the "unmitigated" losses expected for a reference structure defined as having an "average" or "base" combination of construction features. Further discussion of the appropriate reference structures can be found later in the report.

In the course of our work, we have determined that we believe the results discussed below will address every point comprehensively, with two caveats:

- It is very difficult to quantify market responses, in the form of higher property values, to mitigation actions taken by a property owner. Our analysis of the benefits of mitigation has been limited to the reductions in insurable losses for combinations of construction or retrofit features. A professional economic consultancy should be brought to bear to get a fuller picture of market value forecasts for mitigated and unmitigated properties.
- The final section of our report outlines some options, decision points, and considerations for Mississippi officials in implementing a publicly administered and funded mitigation actions program. While we share our experiences from other states and recommendations, we emphasize that AIR is not dictating to Mississippi what should be done and is not necessarily in position to operate as an "outsourcing" entity for the administration of inspections, grants, outreach, and other aspects of the fully developed Program.

That said, we believe AIR is the single entity best qualified to address the broadest number of elements of the Program in our Study and put MID on a path to successful implementation of the Program.

Report Organization

The remainder of this Study is organized as follows:

- Background on AIR's hurricane simulation modeling approach and architecture, including the underlying science and engineering expertise embedded in the software technology and tools used to perform the simulations;
- Background on AIR's individual risk model (IRM), the component of our architecture which assesses the benefits of various construction features of a single structure, justification for the features we consider, and the results of peer review of our identification of the most appropriate features to analyze in this Study;
- Discussion of the data sets used in this Study, including existing AIR data sets, new hypothetical data sets created for analysis purposes, and newly collected data – obtained through help from Mississippi public officials as well as subcontracted surveys - regarding the actual current distribution of the building stock and presence of mitigation features in Mississippi;
- Discussion of the analysis of benefits, including the setup of tables of relative loss costs for each combination of construction and mitigation features, the main assumptions and options used in the analysis, the results of the analysis, and implications of those results;
- Discussion of the approach to and results of cost analysis, including the data sets used, the algorithms employed, the setup of the results tables, and the implications of the results for consumer incentives;

- Observations and recommendations regarding the structure of the Program, including its public administration, public communications and outreach, inspection management, and eligibility for wider sources of funding.

Reliances and Limitations

Data Sets

AIR's exposure databases represent our most complete view of aggregate replacement values, but all databases have limitations. We have developed our exposure estimates using data from multiple sources, along with certain broad assumptions, which we believe are reasonable, regarding gaps in the data.

Data sets generated in the course of this Study are of the best quality obtainable within the scope and timeframe of the Study. We cannot guarantee the completeness or correctness of any data element and the data sets generated by AIR and its subcontractors have been reviewed for reasonableness and consistency, but not independently audited.

Simulation Tools and Scientific Assumptions

Although AIR's simulation methodology is state-of-the-art for estimating potential catastrophe losses, it has certain limitations. It is based on mathematical/statistical models that represent real-world systems. As with all models, these representations are not exact. The simulated events generated by the AIR model do not represent catastrophes that have occurred, but rather events that could occur under scientifically reasonable conditions.

The AIR model relies on various assumptions, some of which are subject to uncertainty. Accordingly, the loss estimates generated by the model are themselves subject to uncertainty. As a result of our ongoing process of internal review, we refine and update our model assumptions from time to time in light of new meteorological and other information as it becomes available. Such refinements and updates may materially alter the loss estimates generated by the AIR model.

Note that extreme occurrence losses - that is, losses in excess of the maximums simulated by the model - are possible, although they have a very low probability of occurrence. It should be understood that the largest simulated event losses do not represent worst possible scenarios.

The loss estimates and their associated probabilities are estimates of the magnitude of losses that may occur in the event of such hazards; they are not intended to predict future events. Actual loss experience, future or past, can differ materially. The estimates function as one of several tools for use in analyzing estimated expected and potential losses from certain hazards. The assumptions that AIR used in creating them may not constitute the exclusive set of reasonable assumptions and methodologies. The use of alternative assumptions and methodologies could yield materially different results.

Results

The tables of relative insurance loss costs, feature costs, and other analysis results reported in this Study are not the exclusive set of reasonable estimates and, because they are generated by models subject to uncertainty and data sets which are subject to quality limitations, are themselves subject to uncertainty. Further, such estimates are not predictions of what will happen in any future catastrophic event and should not be evaluated as such.

As AIR's analysis of the benefits of mitigation has been limited to the reductions in insurable losses for combinations of construction or retrofit measures, other supplemental or "intangible" benefits have not been considered. Examples of "intangible" benefits of mitigation include foregone economic losses other than insured property losses, and foregone societal impacts, resulting from property damage.

Scalability

This study considers only the six defined "coastal" counties in Mississippi. The approach used in this study could, however, be extended to cover other geographic areas. If this were to be done, the insurance benefits would differ due to the variability of the modeled hazard (wind speeds) to which the risks are exposed, but the methodology used to perform this Study would remain applicable.

Distribution, Use, and Reliance on Study

This Study is intended for the use of the Mississippi Insurance Department. AIR assumes no responsibility for use of the Study by third parties or reliance on the Study by third parties for any reason, including but not limited to the setting of insurance rates, taking of construction or mitigation actions, or obtaining public funding for any actions. AIR disclaims all liability in connection with any steps that any person may take to reduce potential damage from high winds. Property owners should consult with qualified construction professionals to determine what wind loss mitigation steps to take and what effect they might have in particular cases.

The client may distribute this Study as needed, but AIR requests notification of distribution of the Study to any third parties, and requests that when distributed, the Study be provided in its entirety. Portions of the Study, including tables, charts, and text sections, viewed out of context may be misleading. AIR will request that the consultants contributing to this Study be available for a limited time to answer questions about it as needed.

Identification of Features

This section opens with a background on catastrophe modeling in general and overall model architecture. This is necessary to understand the broader context in which the individual risk model – the portion of the model that determines hurricane wind mitigation benefits – operates. Next, the individual risk model itself is discussed, including the main construction features considered in mitigation analysis for a specific structure. Finally, our findings from a broader review of relevant features in coastal Mississippi, including subcontracted work and peer review, are synthesized into the final identification and description of the features studied.

AIR's Hurricane Model and Architecture

Rationale for Modeling Catastrophic Events

Natural catastrophes such as hurricanes have tremendous impacts on society in many ways, from the immediate loss of life and property to far-reaching and long-lasting impacts on the economy and insurance system.

Fortunately, large loss events are relatively <u>infrequent</u>. Unfortunately, they are also <u>severe</u> in impact and <u>unpredictable</u> over time, not occurring on regular schedules. It is the combination of these three characteristics that make the estimation of damage and insurance losses from future catastrophes so difficult. The scarcity of historical loss data makes standard economic and actuarial techniques of loss estimation inappropriate for catastrophe losses. Further, the relevance of the loss data that does exist is limited because of the constantly changing landscape of properties. Property values change, sometimes rapidly, along with the costs of repair and replacement. Building materials and designs change, and new structures may be more or less vulnerable to wind loads than were the old ones. New properties continue to be built in areas of high hazard. Finally, it is difficult to understand how losses emerge and should be financed over long periods of time, because storms can strike in any year.

AIR developed catastrophe modeling technologies as alternatives to the actuarial and "rule of thumb" approaches that had previously been relied upon for estimation of potential catastrophe losses. The technical expertise of meteorologists, other physical scientists, engineers, statisticians, actuaries, and computer technology specialists is augmented by the years of experience that AIR has accumulated in this field and integrated into a system for modeling the impact of events. The result is the delivery of reliable and credible loss estimates needed to make informed risk management and public administration decisions.

Basic Model Architecture

AIR developed the first commercial software application for catastrophe modeling based on sophisticated stochastic simulation procedures and powerful computer models of how natural catastrophes behave and act upon the man-made environment. The years since have seen the models undergo a continual process of review, refinement, enhancement, and validation. The ongoing research ensures that the models incorporate the latest advances in the scientific, engineering, mathematical and other fields that are pertinent to their development.

Figure 1 below illustrates the component parts of the AIR state-of-the art catastrophe models. It is important to recognize that each component, or module, represents both the analytical work of the research scientists and engineers who are responsible for its design and the complex computer programs that run the simulations.

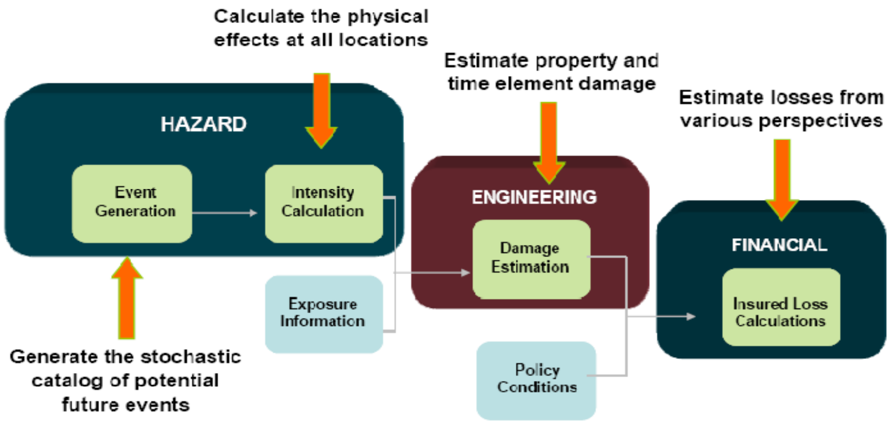


Figure 1: Basic Catastrophe Model Architecture

Hazard: Hurricane Simulation

The event generation module determines the frequency, overall intensity, and other characteristics of potential hurricanes by geographical area. This requires a thorough analysis of the characteristics of historical events. Event generation begins by collecting the available scientific data pertaining to these parameters from many different sources. The data are cleaned and verified. When data from different sources conflict, a detailed analysis and the use of expert judgment is required before they are suitable for modeling purposes.

After rigorous data analysis, AIR researchers develop probability distributions for each of the parameters, testing them for goodness-of-fit and robustness.

Figure 2 shows the major parameters of a simulated hurricane. The selection and subsequent refinement of these distributions are based not only on the expert application of statistical techniques, but also on well-established scientific principles and an understanding of how hurricanes behave.

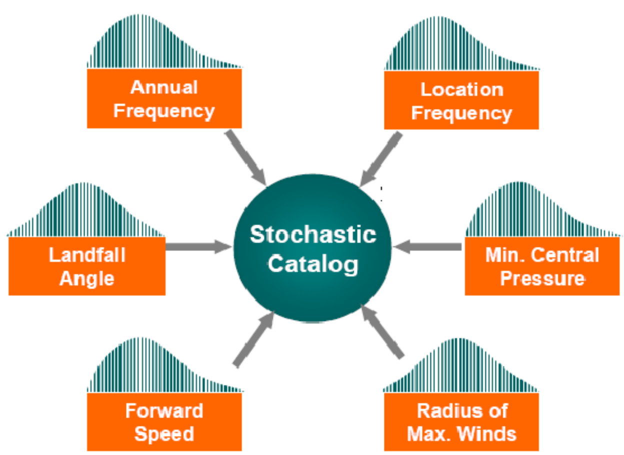


Figure 2: Major Parameters of a Simulated Hurricane

These probability distributions are then used to produce a large catalog of simulated storms. By sampling from these distributions, the model generates simulated “years” of activity. A simulated year represents a hypothetical year of catastrophe experience, but one that realistically could happen in the current year. AIR allows for the possibility of multiple events occurring within a single year. That is, each simulated year may have zero, one, or multiple events, just as might be observed in an actual year such as 2006 (zero landfalling storms) or 2005 (many landfalling storms). Many thousands of these years are generated to produce a complete and stable range of potential annual experience of hurricane activity, and to ensure full coverage of extreme (or “tail”) events, as well as full spatial coverage along the coast.

Mississippi has been impacted by many hurricanes during the last century. According to the HURDAT database maintained by the National Hurricane Center (NHC), seven hurricanes have made direct landfall in Mississippi since the year 1900. An additional 30 hurricanes have made landfall in a 300-mile area between the central coast of Louisiana and the Florida Panhandle. This is significant, since the effects of a hurricane can be scattered across a large area due to the size and complexity of these storms. Hurricanes making landfall in Louisiana can be particularly devastating since wind speeds to the right of the eyewall can be 40-50 mph (64-80 km/h) higher than winds to the left of the eye.

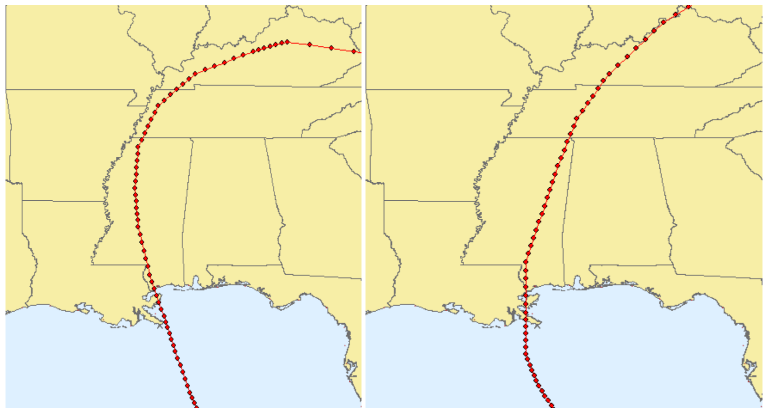
The strongest hurricane to hit Mississippi was Camille, which came onshore as a Category 5 hurricane near the mouth of the Mississippi River on August 18, 1969. With recorded wind speeds in excess of 200 miles per hour, Camille demolished coastal Mississippi and Louisiana. Minimum pressure at landfall in Mississippi was 909 millibars. The only hurricane to hit the United States with a lower pressure at landfall was the Labor Day Hurricane of 1935, which impacted the Florida Keys. The storm surge from Camille reached 24 feet in some places along the coast. The area of total destruction in Harrison County, Mississippi was 68 square miles. Despite mass evacuations, more than 200 people were killed by the storm. Given the devastation, the economic losses were enormous.

Mississippi also suffered heavy damage from Hurricane Katrina in 2005. Among recorded Atlantic hurricanes, it was the sixth strongest overall. In regards to damages, Hurricane Katrina was the largest natural disaster in the history of the United States. Since Katrina made landfall below central Mississippi, 30 miles east of New Orleans, the storm's powerful, right, front quadrant covered coastal Mississippi and southern Alabama, increasing wind and flood damage. The Gulf Coast of Mississippi suffered total devastation with high winds, 55-foot sea waves, and 28-foot storm surge leveling homes and pushing casino barges, boats and debris into towns. The storm left 236 people dead and 67 missing in Mississippi. According to the Property Claim Services (PCS), the total insured losses from Katrina in Mississippi were $13.8 billion.

The storm tracks of Hurricane Camille and Hurricane Katrina are shown in Figure 3 below.

Other hurricanes making a landfall in Mississippi since 1900 include “no name” storms in 1901, 1906, 1912, 1916, and 1926, as well as Elena in 1985 and Georges in 1998. Several additional storms have made landfall in neighboring states, but caused property loss in Mississippi, including Betsy in 1965, Edith in 1971, Babe in 1977, Frederic in 1979, Danny in 1985, Juan in

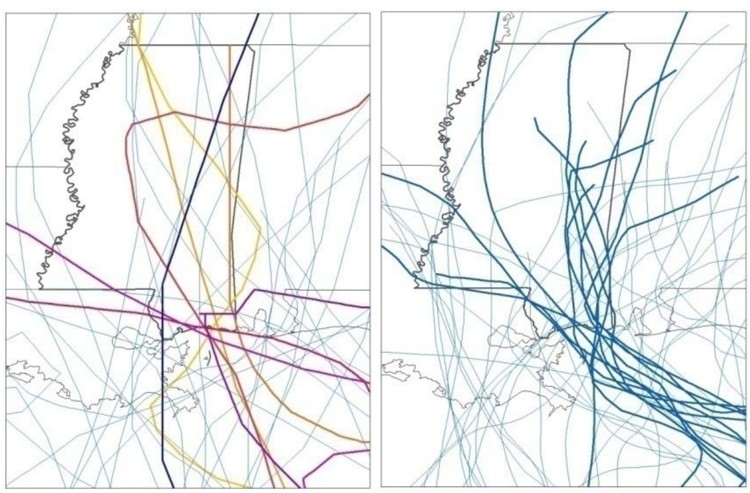
1985, Florence in 1988, Erin in 1995, Lili in 2002, Ivan in 2004, Cindy in 2005, Dennis in 2005, Rita in 2005, and Gustav in 2008.



(a) Hurricane Camille (1969) (b) Hurricane Katrina (2005)

Figure 3: Storm Tracks of (a) Hurricane Camille (1969) and (b) Hurricane Katrina (2005)

The storm tracks of hurricanes making landfall in Mississippi during the 108-year period from 1900-2007 are shown in Figure 4 below. The figure also shows a sample of simulated storms tracks generated over a 108-year simulation period by the AIR US hurricane model. The overall pattern of the model generated tracks is generally in good agreement with the pattern of the historical tracks.



(a) Historical (b) Simulated

Figure 4: Maps of Mississippi (a) Historical and (b) Simulated Storm Tracks

Figure 5 shows a comparison of the intensity distribution of historical and simulated storms at landfall. The storms are grouped by Saffir-Simpson category based on central pressure, and displayed for 300 nautical miles of coast surrounding Mississippi. As can be seen from the graph, the landfall intensity of the simulated storms is in good agreement with the intensity of historical storms making landfall in this region.

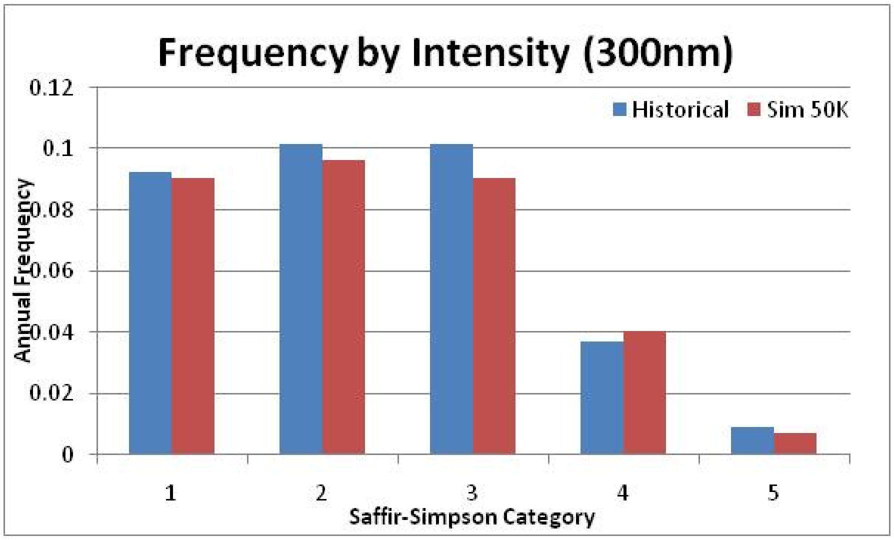


Figure 5: Comparison of Historical and Modeled Hurricane Frequencies by Saffir-Simpson Category around Mississippi Coast

Hazard: Local Intensity

Once the model generates the characteristics of a simulated storm, it propagates the event across the affected area. For each location within the affected area, local intensity – a function of a variety of local conditions -- is estimated. Hurricane local wind speed estimates call upon high resolution databases of surface terrain and land use/land cover (LULC) characteristics. Using this data, AIR calculates a surface friction coefficient to obtain an estimate of surface roughness, which influences how quickly wind speeds dissipate over land. Researchers base local intensity formulae on empirical observation as well as on theoretical relationships between the variables. An example of the results – a “footprint” of maximum wind speeds at each affected location – is shown in Figure 6.

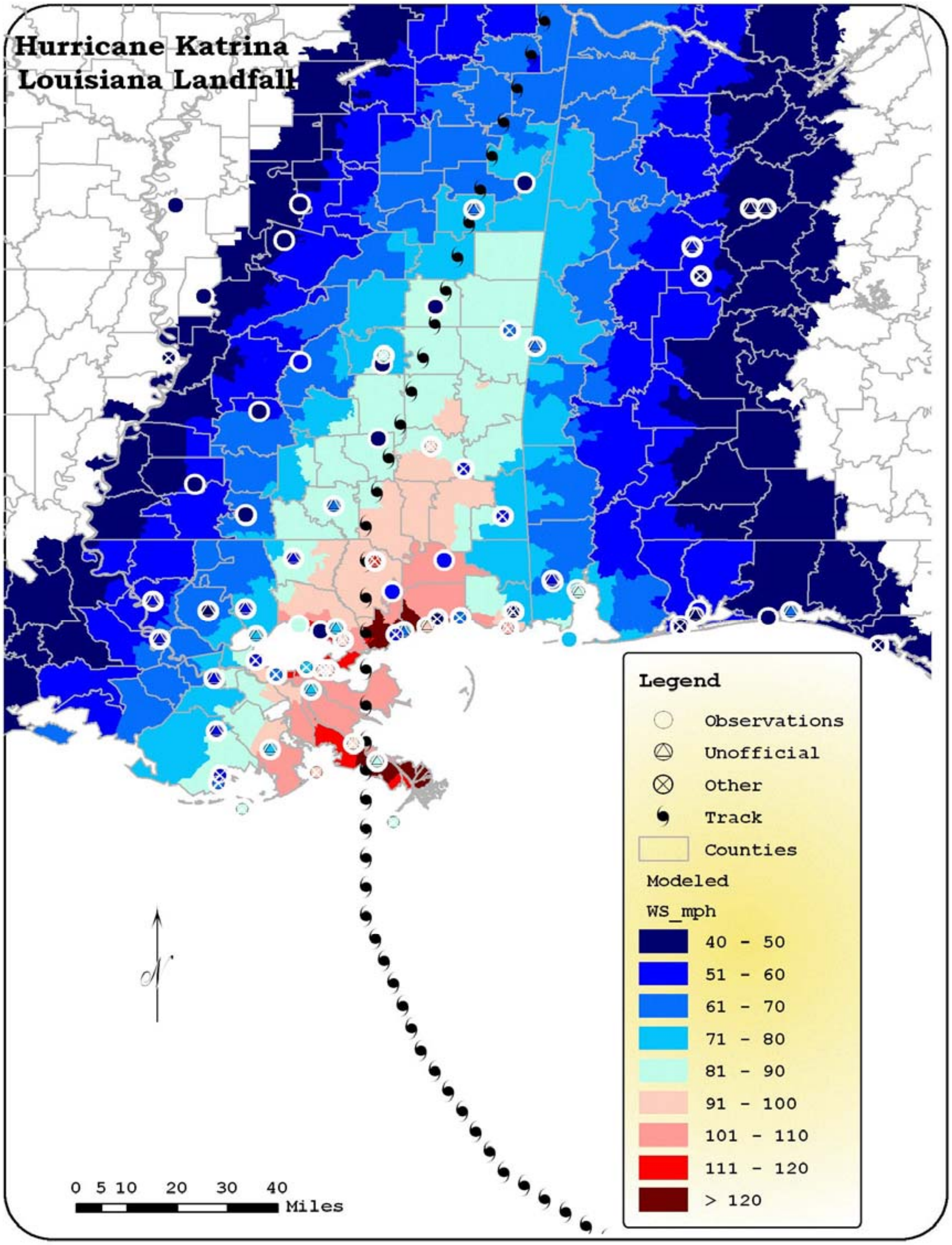


Figure 6: Modeled Wind Footprint for Hurricane Katrina

Vulnerability: Damage Functions

AIR scientists and engineers have developed mathematical relationships called damage functions, which describe the interaction between buildings - structural and nonstructural components as well as their contents - and the local intensity to which they are exposed. Damage functions have also been developed for estimating time element losses. These functions relate the mean (average) damage level, as well as the variability of damage, to the wind speed profile at each location. Because different structural types experience different degrees of storm damage, the functions vary according to number of stories, construction type and occupancy. As illustrated in Figure 7, the AIR model estimates a complete distribution around the mean level of damage – allowing for the possibility of zero damage and 100% or "total loss" damage - for each storm footprint and each structural type.

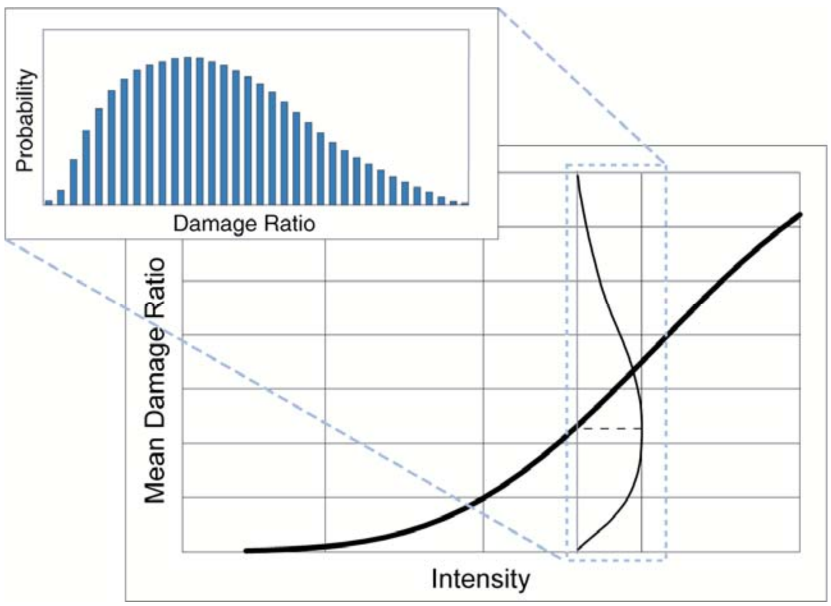


Figure 7: Representative Residential Damage Function

Losses are calculated by applying the appropriate damage function to the replacement value of the insured property. This fact has an important implication, which is that modeled losses are only as good as the replacement values which underpin them. For example, if replacement values are understated by 50%, the modeled losses will be as well. This is why using exposure data of the highest possible quality and completeness is critical to obtaining the most reliable model results.

The vulnerability relationships incorporate the results of well-documented engineering studies, tests, and structural calculations. They also reflect the relative effectiveness and enforcement of local building codes. AIR engineers refine and validate these functions through the use of post-disaster field survey data and through exhaustive analysis of detailed claims data as it becomes available after events.

Financial: Aggregating Losses

Raw damage estimates must be collected for each coverage at each location within each policy, and proper policy terms applied, to yield the insurable losses for the exposure at hand. The final component of the catastrophe model, the financial module, aggregates damage and converts to losses as viewed from whatever perspective is relevant – for example, first-dollar ("ground-up"), paid by an insurance company after deductibles and policy limits ("gross"), or "net" of reinsurance. Policy conditions may be rather complex, including deductibles by coverage, site-specific or blanket deductibles, coverage limits and sublimits, loss triggers, coinsurance, attachment points and limits for single or multiple location policies, and risk-specific reinsurance terms. However, in this analysis the main perspectives of interest are ground-up losses and insured losses gross of a standardized deductible.

Aggregation of losses while preserving the uncertainty in the simulated damage distribution is not as easy as just adding up losses by coverage/location/policy; a statistical technique called "numerical convolution"[2] is applied to each simulated storm loss for each policy/location to get an accurate representation of the total loss, including the variability of the total loss around its average value. The technique is illustrated in Figure 8 below.

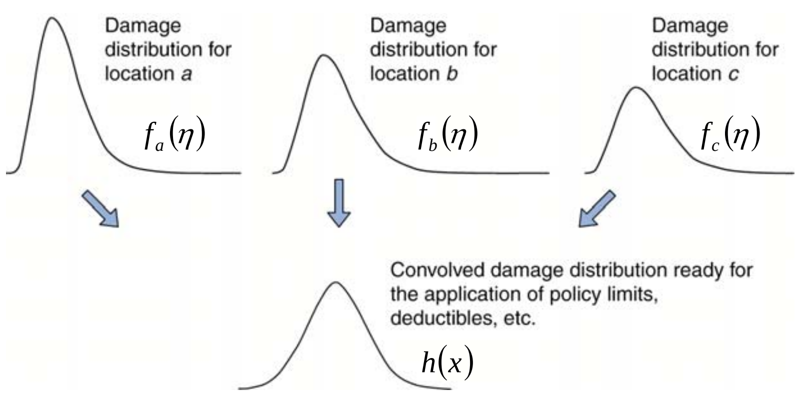


Figure 8: Damage Distribution Convolution Logic

The solution obtained is the most theoretically sound and yields the most precise results, preserving and propagating uncertainty through the roll-up of losses by coverage, location, and policy for each event.

Interpreting Model Output

The results of simulating the entire catalog of storms against the exposure at hand are condensed into outputs for the end user. The fundamental result is the complete probability distribution of losses, also known as "exceedance probability" (EP) curves. EP curves can be assembled in two main ways: "annual occurrence" (largest event in each simulated year) or

[2] A full description of the technique is beyond our scope, but the essentials are illustrated by example. To convolve the losses for two locations on a single policy, the model computes every possible combination of losses at the two locations, weighted by their respective probabilities, which could result in a given combined loss amount. It repeats that calculation for every possible combined loss amount, and the result is a convolved (combined) probability distribution of losses for the policy. It is similar to the calculation of the probability of getting a certain sum (e.g. 2, 3, ...12) when rolling two dice.

"annual aggregate" (sum of all losses in each simulated year). They can also be viewed from the ground-up, gross, or net loss perspectives.

The probabilities can also be expressed as "return periods." Sometimes this is more intuitive. That is, the loss associated with a return period of 20 years is likely to be exceeded in only 5 percent of years, or on average, in one year out of twenty. Figure 9 below illustrates a sample (not applicable to this analysis) EP curve. Any loss amount of interest (read on the horizontal axis) can be paired with the probability that occurrence or annual losses exceed that amount (on the vertical axis) by consulting the curve.

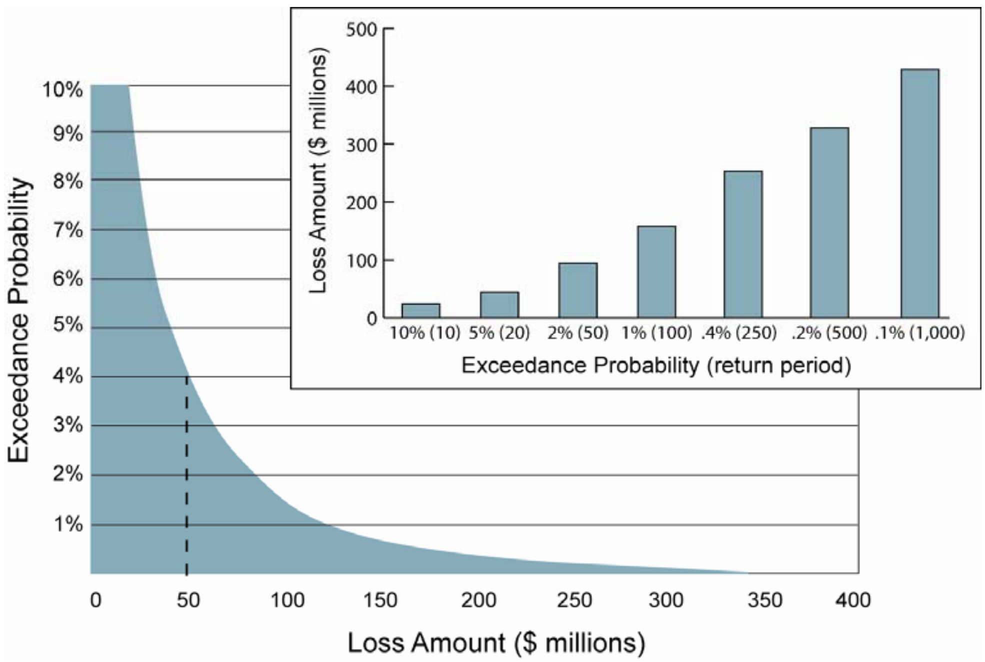


Figure 9: Sample Exceedance Probability Curve

Output may be customized to any desired degree of geographical resolution down to location level, as well as by line of business, by construction class, and so on. The model also provides summary reports of exposures, comparisons of exposures and losses by geographical area, and detailed information on potential large losses caused by extreme "tail" events.

For this Study, the most important statistic is not any particular percentile of the loss distribution, but the average annual losses (AAL) at each modeled location, for all the possible construction and mitigation feature combinations modeled at that location. "Loss costs" are AALs per unit of exposure (the standard unit of exposure is $1,000 in this Study). The loss costs for various feature combinations are compared to one another to determine the insurance benefits of mitigation measures. The makeup of our data sets for modeling is discussed further below.

Scientific Basis of Hurricane Wind Model

The wind profile of a hurricane over space (the area affected by the footprint) and time (the duration of damaging winds at each location) is developed using the following simulated parameters for each storm:

1. **Frequency of occurrence**: number of storms affecting each area of the coastline in a season;
2. **Landfall location**: number of landfalls affecting each "coastal segment" of fifty nautical miles;
3. **Heading at landfall**: compass direction of movement of the storm center at landfall;
4. **Minimum central barometric pressure**: intensity of storm at landfall;
5. **Radius of maximum winds**: distance from center of storm to the eye wall;
6. **Forward speed**: velocity of the storm center at landfall.

Once the model determines these meteorological characteristics, it simulates the storm's movement along its track. Calculations of local intensity take into account the effects of the asymmetric nature of the hurricane windfield, storm filling over land, surface friction, and relative wind speed profiles. The generation of local windfields is a complex procedure requiring the use of many variables. First, the maximum over-water wind speed is calculated. Adjustments are then made for asymmetry effects, filling, surface friction, and relative wind speeds as a function of distance from the eye.

In the Northern Hemisphere, hurricane winds rotate in a counter-clockwise direction. The combined effects of hurricane winds and forward motion produce higher wind speeds on the right-hand side of the storm. The model accounts for the dynamic interaction of translational and rotational speeds, and the inflow angle.

The effect is visualized in Figure 10 below.

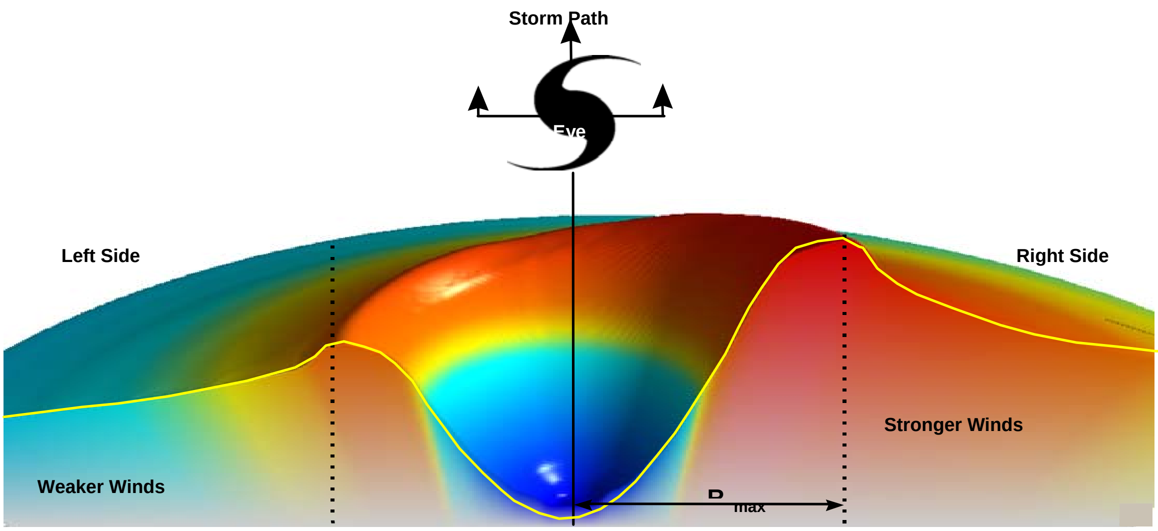


Figure 10: Windfield Cross Section

As the storm moves inland, its intensity begins to dissipate. Central pressure rises and the eye of the hurricane begins to "fill" as it moves away from its energy source, warm ocean water. The model's filling equations are functions of the geographic location (particularly distance from coastline), and time elapsed since landfall. Rates of fill also vary by region, as is consistent with historical observation.

Differences in surface terrain also affect wind speeds. Wind velocity profiles typically show higher wind speeds at higher elevations, as depicted in Figure 11 below. Winds travel more slowly at ground level because of surface friction. The initial step in calculating the friction coefficient for each point of interest is to obtain an estimate of the surface roughness at the site. At ground level, horizontal drag forces induced by the surface roughness are exerted on the wind flow, causing retardation of the wind near the ground. The surface roughness is estimated based on high-resolution digital USGS land use/land cover data. The LULC categories vary from urban or built-up land, to agricultural land, to forest land or wetlands, to water. Each terrain type has a different "roughness value" that leads to different frictional effects on wind speeds. In general, the rougher the terrain the larger the frictional effect on wind speeds. The magnitudes of the friction coefficients in the AIR model are consistent with accepted scientific literature and empirical hurricane wind speed data.

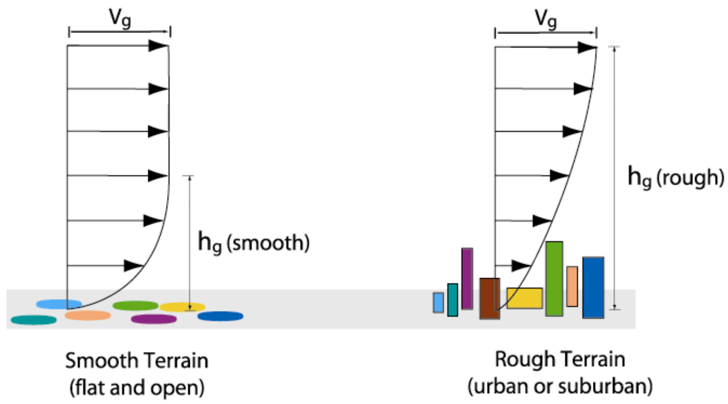


Figure 11: Terrain Effects on Wind Speed Profiles

Finally, the wind speed at any particular location is dependent on the radial distance between the eye of the storm and the location of interest. Figure 12 illustrates a range of relative wind speed profiles for different radii of maximum winds. Note that the ratio of the velocity at a given location to the maximum velocity equals 1 at the radius of maximum winds and then drops off as distance from the eye increases.

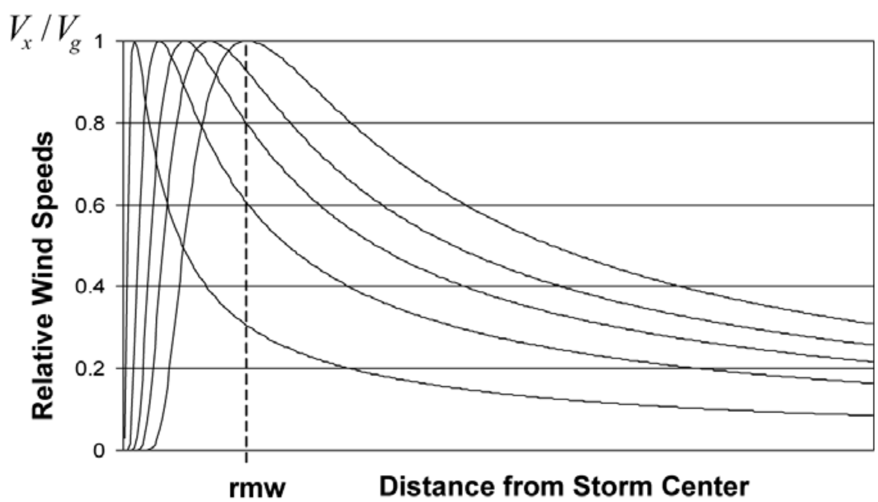


Figure 12: Relative Wind Profiles

AIR researchers validate windfield calculations by comparing the recorded wind speeds of historical storms to those generated by the model.

Damage Calculations for Hurricane Wind

AIR engineers have developed hurricane wind damage functions to provide detailed breakdowns of loss estimates by coverage, construction class, and occupancy. Major occupancy classes (Homeowners, Apartments/Condos, Commercial, Industrial and Autos) are further broken down into distinct construction classes. These include light metal, wood frame, joisted masonry, unreinforced masonry, reinforced masonry, reinforced concrete, steel frame, and mobile homes.

The vulnerability functions have been developed by experts in wind and structural engineering and are based on published engineering research and engineering analyses. The functions have been validated based on results of damage surveys and actual claims data provided by client companies. Further discussion of the effect of original data collected for this Study on our engineering opinions underlying the estimated insurance benefits of various features appears later in the report.

The development of commercial damage functions presents a somewhat greater challenge than the development of residential functions, due primarily to the relative scarcity of detailed loss data with which the relationships are fine-tuned and validated. Commercial structures are, on average, less vulnerable to wind damage, so the absolute amount of industry loss data is smaller to begin with. Further, for multi-location policies, losses paid centrally to a corporate headquarters often do not include information about the actual damaged property.

Component-Based Approach

AIR wind engineers have developed a component-based engineering approach for the development of damage functions. The resulting functions have been validated by external experts from leading wind engineering institutions.

Figure 13 shows a schematic of AIR's component-based engineering approach for the development of damage functions. Several building components and attributes that affect building vulnerability to hurricane winds are considered. These can be divided into three broad categories: a) the primary attributes that deal with the occupancy, material and the height of the building; b) secondary attributes that define the building envelope, such as roof, cladding material, and size of openings; c) other attributes, including amount of engineering attention, wind hazard and repair cost, which affect building vulnerability indirectly. The relative impact on vulnerability of each component or attribute is obtained from a variety of sources, including experience gained from post-event reconnaissance and input from wind engineering experts.

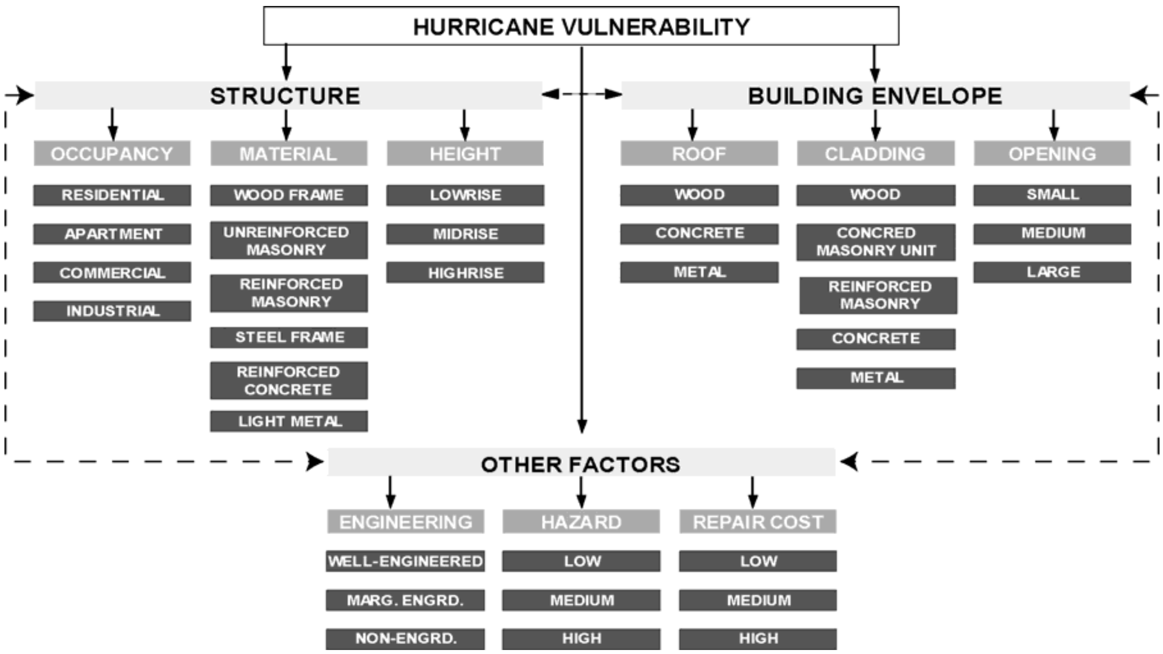


Figure 13: Component-based Vulnerability Model

AIR damage functions explicitly account for building height. Separate damage functions have been developed for each of three height ranges: 1 to 3 stories, 4 to 7 stories, and more than 7 stories. We know from wind speed profiles that wind speeds increase with height. For a given storm at a given location, a low-rise building may experience Category 1 wind speeds, while the upper floors of a 20-story building may experience winds corresponding to a Category 5 hurricane. This is illustrated in Figure 14 below. On the other hand, while the wind hazard increases with height, vulnerability typically decreases. High-rise buildings are less vulnerable since they are generally well-engineered, built to strict building code requirements and, unlike residential structures that may have gabled wood frame roofs, have wind-resistant flat slab roofs.

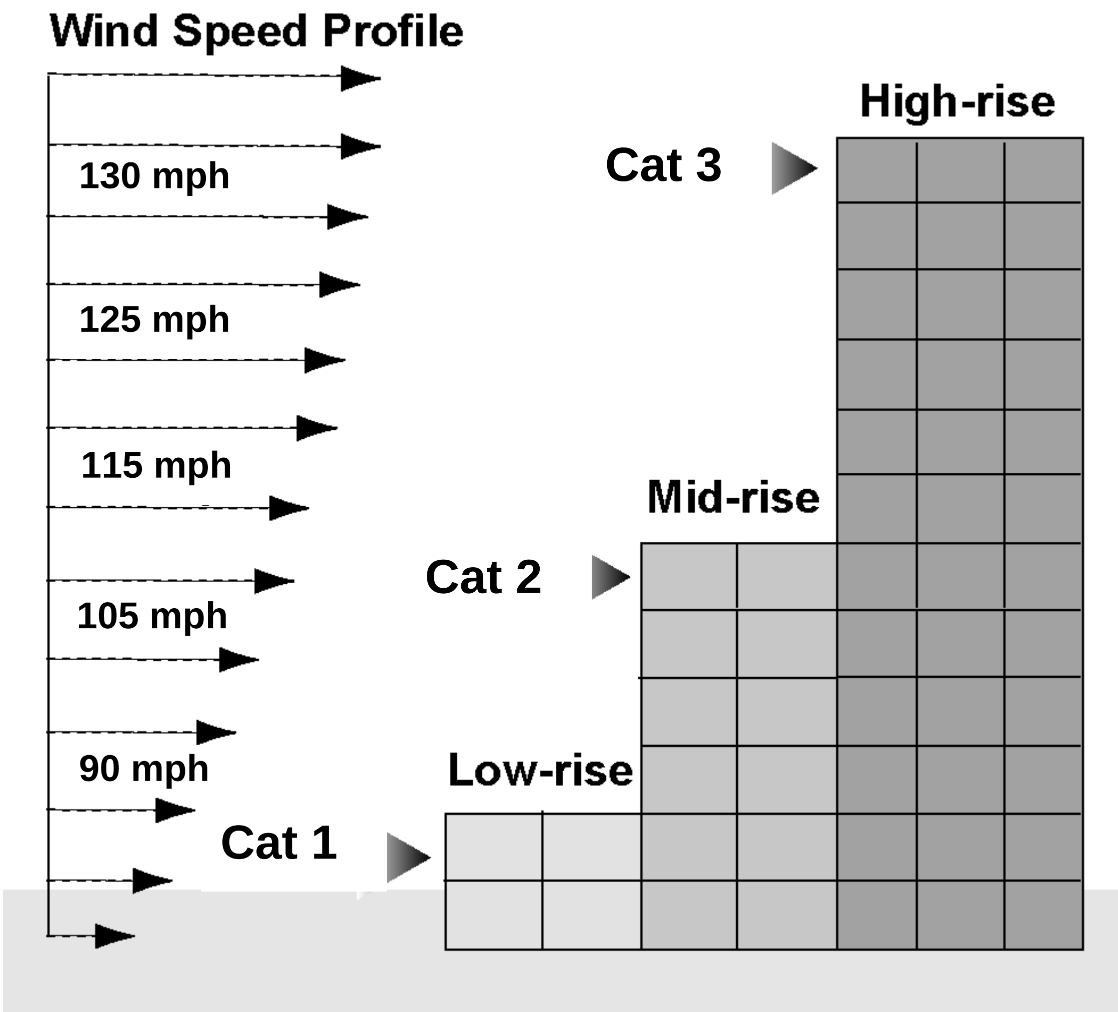


Figure 14: Variation in Wind Hazard by Height

Mid- and high-rise apartment and condominium buildings usually receive a similar degree of engineering attention to that of commercial construction. Nevertheless, apartments and condominiums have some building components that make them more susceptible to windstorms than commercial construction, such as balconies, awnings, and double sliding glass doors. These components are less engineered at the design and construction stages and hence lead to greater vulnerability as compared to commercial construction.

The model provides the option to evaluate the impact of many individual risk characteristics of a building's components, each of which can enhance or reduce vulnerability to wind damage. These may include roof geometry and pitch, roof covering, window protection and glass area, exterior doors, and other features.

Damage Functions at the Coverage Level

Separate damage functions for each of building, contents, and time element coverages provide estimates of the mean, or expected, damage ratio corresponding to each wind speed. In addition, they provide probability distributions around each mean (recall Figure 7 above). This way, the model ensures non-zero probabilities of zero and total (100%) loss, reflecting the wide variation in observed damage at adjacent locations experiencing the same local intensity in a storm.

In the case of building damageability, the damage ratio is the dollar loss to the building divided by the corresponding replacement value of the building. The contents damage ratio is the dollar loss to the contents divided by the replacement value of the contents. Contents damageability is a function not only of building type, but also of occupancy class. That is, for each occupancy class there exists a contents damage function, which itself is a function of the building damage ratio. Occupancy provides information on the likely contents present and hence their potential vulnerability.

In the case of time element, the damage ratio represents per diem expenses or business interruption losses associated with the expected number of days that the building is uninhabitable (residential) or unusable (commercial). Time element damageability is a function of the mean building damage, as well as the time it takes to repair or reconstruct the damaged building. The functional relationship between building damage and loss of use is established using detailed published building construction and restoration data and on engineering judgment. Estimated time element losses have been validated using actual time element loss data from client companies.

In this analysis, we are primarily concerned with the relative damageability of structures with various construction types and mitigation features, so the emphasis will be on the structure damage functions.

Modeling Damage due to Wind Duration

The AIR hurricane damage estimation module develops a complete time profile of wind speeds for each location affected by the storm, thus capturing the effects of wind duration on structures as well as the effect of peak wind speed.

Design loads are sometimes exceeded in tropical cyclones or hurricanes. With no reserve strength, a fastener or connector that has been pulled out or pulled through as a result of uplift load can compromise the integrity of the building envelope. Wind damage manifests at the weak links in a structural system. As each connector is overwhelmed, loads are transferred to the next point of vulnerability. The longer the duration of high winds, the longer this process continues and the greater the resulting damage.

The cumulative effects of winds can be examined using a dynamic approach. In order to estimate damage to a property at any point in time, it is important to take into account the extent of the damage that has occurred in the preceding period. Each damage ratio is applied in succession to the remaining undamaged portion of the exposure from the preceding period. Figure 15 illustrates this process.

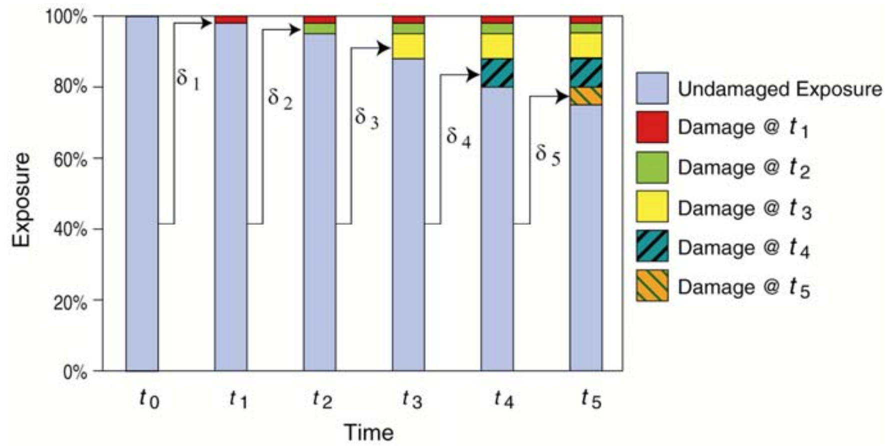


Figure 15: Measuring the Cumulative Effects of Winds

At t_0, before even tropical storm force winds have reached the site, there is zero or negligible damage. At time t_1, with wind speeds near 60 mph, the damage ratio δ_1 is calculated as a percentage of the full replacement value. At t_2, the damage ratio δ_2 is applied to that percentage of the property that was left undamaged in the previous period. This process continues until wind speeds once again fall below tropical storm strength.

Calculating damage only when winds are at their maximum and applying a single damage ratio to the full replacement value would not account for the cumulative effects of prolonged winds.

AIR's Individual Risk Model

Within the vulnerability module of AIR's hurricane model is a specific subsidiary model for individual risk analysis. This is the part of the modeling architecture which operates on what catastrophe modelers call "secondary modifiers," or detailed construction features - those beyond the overall construction type, year built, and height – introduced to the model in a property data record. It may be visualized as a smaller box within the Engineering module in Figure 1 showing basic model architecture.

The Individual Risk Model (IRM) was developed using a knowledge-based expert system and a structured approach. Based on structural engineering expertise and building damage observations made in the aftermath of historical hurricanes, more than 30 building features have been identified as having a significant impact on the building losses. The most relevant to the scope of this project are used in the insurance benefits and feature costs analysis in this Study.

Options or categories for each feature are identified based on construction practice. Algorithms for modifying the vulnerability functions[3] are developed based on engineering principles and

[3] The IRM modifies damage functions for each coverage (structure, contents, time element) separately and distinctly. The effect of a feature on structure damage may not bear a close relationship to its effect on time element damage.

building performance observations. The modification captures the changes to building vulnerability that result when certain features are present and when information on such features is known. The function varies with the wind intensity to reflect the relative effectiveness of a building feature when subjected to different wind speeds.

The first step in the development of the individual risk model is to identify building and environmental characteristics that impact the performance of a building in high winds. These features are selected based on academic research and its controlled experiments, as well as knowledge of building performance in high winds as obtained in the course of hurricane damage surveys. The AIR model includes four groupings of building and environmental features that influence damageability. These are:

- Nonstructural features (e.g. wall siding);
- Structural features (e.g. roof and wall systems);
- General building features (e.g. building condition, occupancy);
- Environmental features (e.g. tree exposure, surrounding terrain).

Note that the IRM supports any combination of multiple building features and produces an integrated modification function to the vulnerability function. In other words, the IRM does not operate in a simple “additive” or “multiplicative” fashion – every combination is different, and that is why the resulting relative loss cost tables below are so complex.

Figure 16 shows the schematic of the IRM. The model considers each building to be an assemblage of many building components. Each building component can have many subcomponents. For example, a roof system is made up of subcomponents for roof covering, roof decking, and roof attached structures. Each building component and its subcomponents are associated with certain building features that can affect the overall vulnerability.

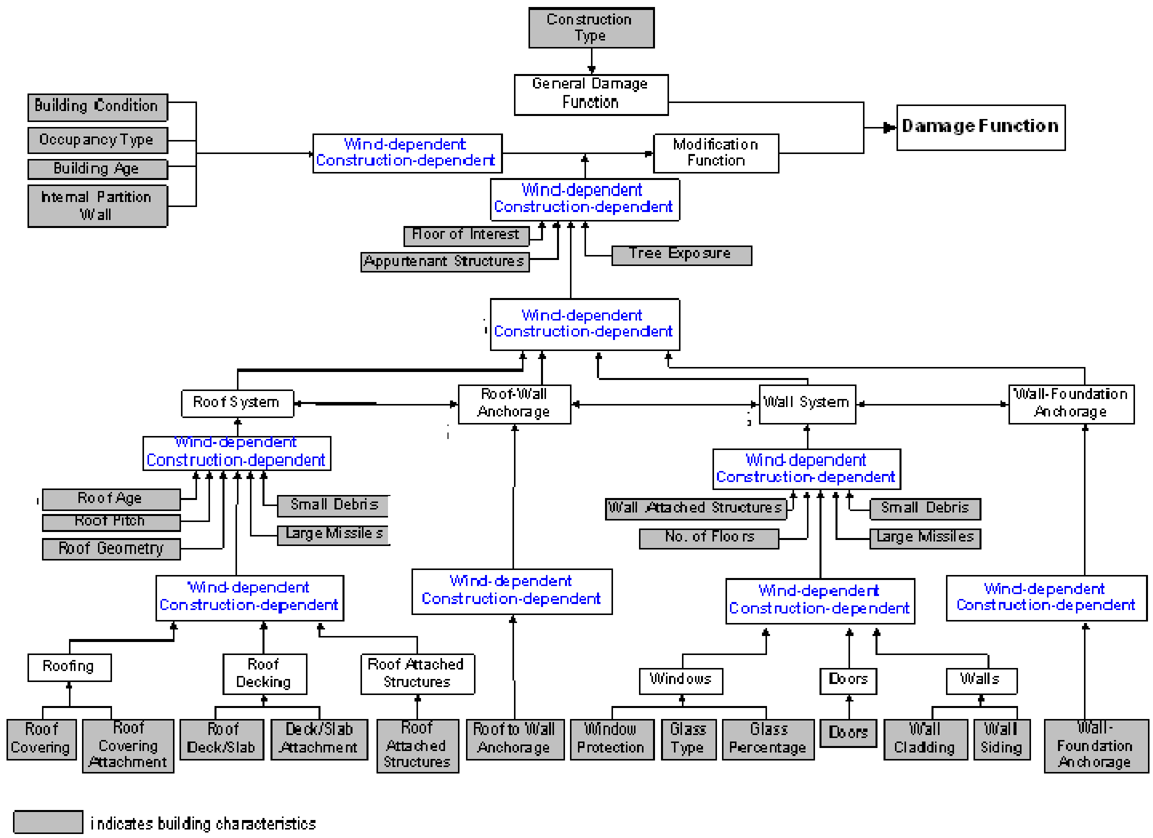


Figure 16: Evaluation of Building Performance in the AIR Individual Risk Model

Embedded in the IRM are two primary metrics — rates and weights — for evaluating the impact of a building feature (e.g., roof covering type) or building environmental feature (e.g., tree exposure) on overall building performance. The rate is a weighted value assigned to the various "options" for building or environmental features. The rate for any given option of a particular feature reflects the relative prevalence of use among the available options, and is independent of other features. That is, the value is designed such that the most commonly used option is assigned a value close to 1.0. The implication is that a building with this option is expected to perform very similarly to the average, or "typical" building represented by the base damage functions.

An option that is considered to be more vulnerable (i.e. less wind resistive) than the more commonly chosen options will be assigned a rate greater than 1.0. That is, a building with this option will be more vulnerable than the average building to damage from wind. Similarly, the rate assigned for an option that is considered to be less vulnerable (i.e. more wind resistive) than the most prevalent one will be less than 1.0. Such a building will be less vulnerable than the average building. The value for a given option is a constant. If no information is available on the option, the default value is 1.00, which means that the base damage function is used without modification.

The second metric, the weight, is a value of one of two types. The first weight type is used to develop simple weighted averages which are used to evaluate the loss contribution of several features that together constitute a system, such as roof. They are wind speed dependent; the contribution of each feature varies with wind speed. For example, a roof may consist of three features: roof covering, roof deck and roof attachment. The loss contribution to the roof system from these three features is expected to be different at different wind speeds. At low wind speeds, the roof covering drives the damage since it is at relatively low wind speeds that damage to roof covering occurs. As wind speeds increase, the roof deck becomes vulnerable. In this case, roof deck failure will result in loss of roof covering regardless of the type (or option) of roof covering present. Therefore, as wind speed increases, the weight for roof deck increases. In contrast, at higher wind speeds, the weight for roof covering decreases because it is already lost. The sum of the weights for a system should add up to 1.0.

The second type of weight metric is used to combine the effects of features whose interaction is complex and not necessarily additive. These are introduced to evaluate features that modify the performance of the system. Consider the roof system as an example; the age, pitch, and geometry of the roof all modify the performance of the system as a whole. Hence the weight should be used as a multiplier. Weights are dependent on wind speed and construction class, and are appropriately selected to reflect the importance of a feature at certain levels of a building's damage state.

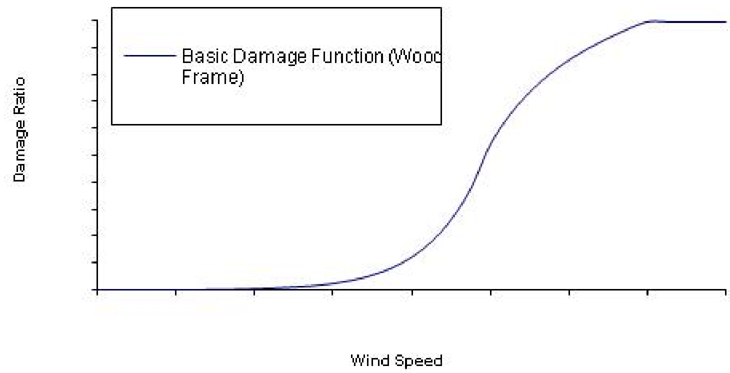
The general nature of the IRM framework allows estimation of the loss relativities for a wide variety of building types prevalent in hurricane prone areas. To estimate loss relativities for a building built to a specific building code, appropriate features and the options for those features can be selected in the analysis to estimate the building damageability.

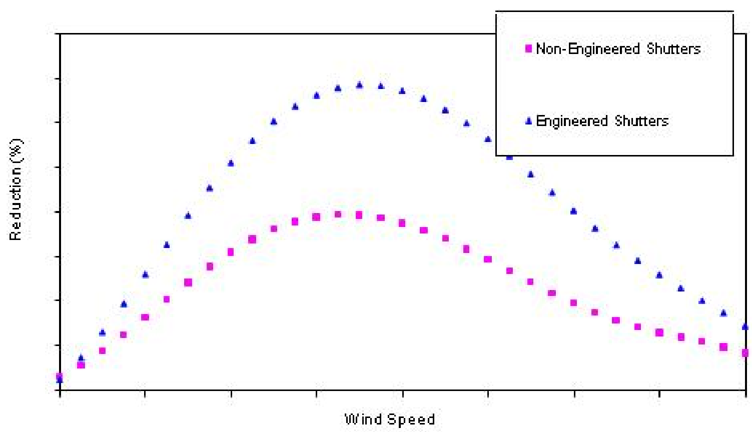
The Individual Risk Model has been developed and reviewed by wind engineering experts, and has been accepted by the Florida Commission on Hurricane Loss Projection Methodology since its inception in 1996.

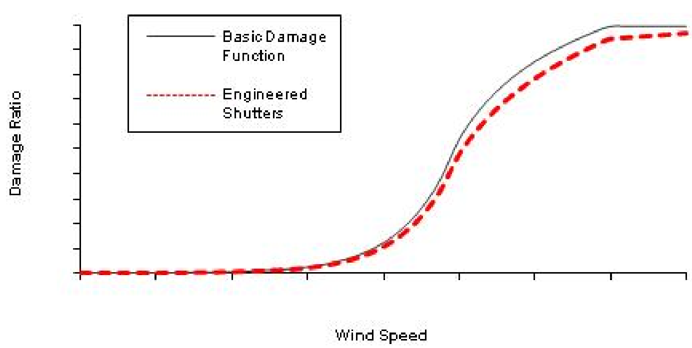
How the IRM Operates on Building Features

Figure 17 illustrates the application of modifications for storm shutters to the basic damage functions for a given AIR construction type code - in this case, wood frame. The basic function assumes a status of “unknown” for the presence of storm shutters. The implications of coding a feature as “unknown” in an exposure data record are very important and will be discussed later in detail.

Modifications for non-engineered shutters (e.g. removable plywood covers) and engineered shutters (e.g. metal roll-up type) are stored in the IRM. When a data record is introduced to the model with no information about storm shutters, the “unknown” basic damage function for the construction type is used. When a data record containing specific knowledge about storm shutters – engineered present, non-engineered present, or none at all present – is introduced, the damage function is modified according to the IRM. A property known to have no storm shutters will be modeled as slightly more vulnerable than average, raising its relative losses and showing a debit for lack of mitigation, but a property with non-engineered shutters will be modeled as somewhat less vulnerable and show a “mitigation credit” in the relative losses, and of course a property with engineered shutters will show even less vulnerability and a higher “mitigation credit.”







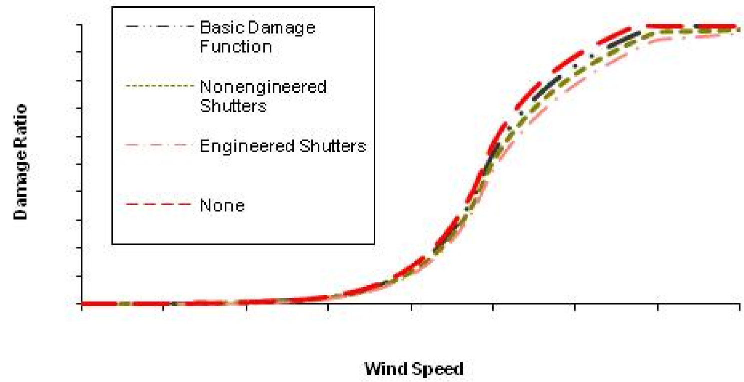


Figure 17: Example of Applying Mitigation Adjustment to Basic Damage Function

Individual Risk Model Validation

AIR's rigorous validation process is not just limited to the final model results. Throughout the model development process, every component is carefully verified against data from historical events. Of course, the goal of catastrophe models is not simply to replicate the historical record; the model should reflect the full range of potential future catastrophe experience, including the most extreme events - events that may not have occurred historically. Therefore it is critical that the model be vetted and validated by the domain experts—both internal and external—for each model component to ensure reasonability.

To validate the IRM, AIR's engineers conduct detailed damage survey investigations, analyze claim reports and utilize engineering judgments. Damage surveys as well as engineering analysis indicate that building features such as opening protections can significantly mitigate building damage. However, this level of detailed information is generally not available in the claims data to estimate the marginal or combined effects of different building features. Recently, due to insurance incentives in some states for homeowners for use of mitigation features, many insurance companies have started collecting detailed building feature data in those areas. Over time, it is expected that claims data will include more detailed information regarding these features. Most recently AIR has received claims data for Florida from the 2004 and 2005 hurricane seasons that contain detailed building features information. At this time, such detailed information is not available for Mississippi.

Figure 18 shows the comparison between modeled and actual percentage reduction in vulnerability due to mitigation features, using sample company data. It is clear from the figure that all of the key mitigation features provide significant reductions in vulnerability. Though there can be variation in actual reductions seen in any given data set, model results are similar to those observed in the data.

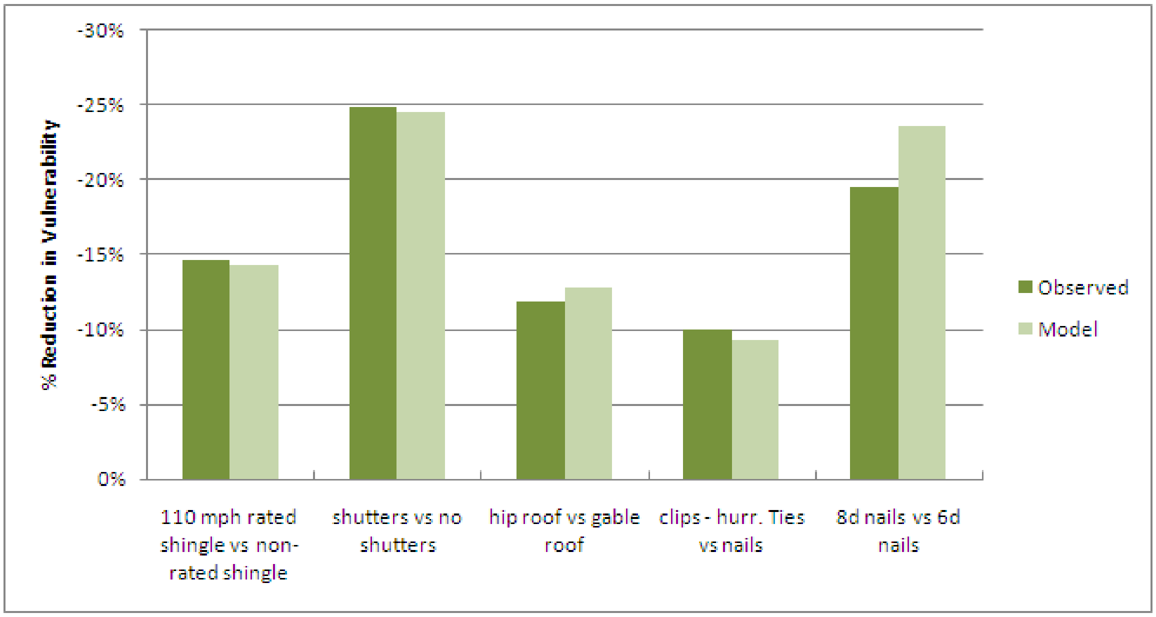


Figure 18: Comparison Between Modeled and Actual Reduction in Vulnerability for Sample Company Data

How Exposure Data is Introduced to the Model

Each structure subject to the analysis is described to the model in the form of a data record. The AIR data format includes fields for the following major attributes of a property:

- Identifying information (policy and location number, line of business);
- Geographic location (street address, city and ZIP Code which the model converts to a latitude-longitude pair or “geocode”);
- Replacement value (by location and coverage);
- Insured values and policy terms (limits and deductibles by coverage, how the deductibles are applied; any sublimits, “layers,” or per-risk reinsurance by location and policy);
- Primary property attributes (construction type, occupancy type, year built, height in number of stories);
- “Secondary modifiers” to property attributes (mitigation features, detail of surroundings).

This Study focuses on the impact of the primary and secondary property attributes on the insurable loss costs under simple, common policy conditions (such as a single location deductible per storm, no reinsurance, and an insured limit equal to replacement value).

By varying the construction types, heights, and mitigation features in otherwise equal property data records, we determine the effect of the IRM on the loss costs and thus the indicated insurance benefits associated with more or less reinforced structures in various locations around the Mississippi coast. This "notional portfolio" approach is discussed further below.

Choosing Relevant Features for Mitigation Analysis

The most relevant of the IRM features to the scope at hand have been analyzed in this report. The features are chosen based on the following criteria:

- Effect on relative hurricane wind damage (measured by average annual losses) to those for a "base" structure in which secondary modifiers are unknown, and to base structures with combinations of features common in Mississippi;
- Ability to define the feature and describe it in a finite number of common categories;
- Ability to recognize the feature category in either a "drive-by" or more detailed property inspection, to report it on typical insurance applications, and to store it in policy exposure data used for catastrophe modeling;
- Practical challenges in the degree of knowledge of construction features of any particular structure.

The effect on loss cost is in turn determined by both existing AIR research embedded in the IRM, as discussed above, and consultation and review by academic experts with knowledge of local conditions and construction practices, as discussed below.

There is also a complex interaction between the basic construction type and the relevant features for that type. For example, the roof geometry, deck attachment method, and anchorage to walls are far less relevant for high-rise concrete and steel office buildings with reinforced concrete roof decks than they would be for low-rise residential buildings.

The final approach reflects mitigation classification architecture and the fundamental guiding principle stated as follows: a non-technical agent or data collector, given varying amounts of information about common structures in coastal Mississippi, should be able to use this report to classify structures for insurance purposes with respect to vulnerability against a reference or "base" structure of the same type.

Both the credibility of the features chosen for the analysis of benefits of mitigation, and the choice of the reference structure within each construction type, are critical for the actuarial implementation of the Study. This is because current insurer rating plans typically already consider construction type (and sometimes year built and height) but often do not consider specific credits and debits for specific mitigation features. By and large, structures modeled as "unknown" with respect to mitigation features are the structures underlying the base rates in existing insurer rating plans. Care should be taken in "bolting on" a mitigation factor table(s) to these plans to minimize the actuarial re-balancing (adjustment of base rates) needed to maintain actuarial soundness of the plans. AIR has included analysis of the building stock data collected for coastal Mississippi in this Study to assist MID in determining the most common combinations of features which could be represented as the “base” structure within the insurance benefits analysis for each construction type.

Not all features were modeled for all structure types, as certain combinations of height, construction type, and mitigation features do not apply or do not make sense.

Feature Definitions and Descriptions - Residential

The following section outlines the set of construction features we have determined are most relevant to the scope of this Study and offer the greatest potential insurance loss cost benefits.

Roof Geometry

Roof geometry largely determines the magnitude of aerodynamic loads experienced by a particular roof. The geometry affects the intensity of wind pressures and the resulting uplift resistance. Common roof shapes are gable (with or without end bracing) and hip, although a variety of roof shapes are possible. A brief description of some of the roof shapes is provided below.

Gable Roof. This roof slopes in two directions so that the end formed by the intersection of slopes is a vertical triangle.

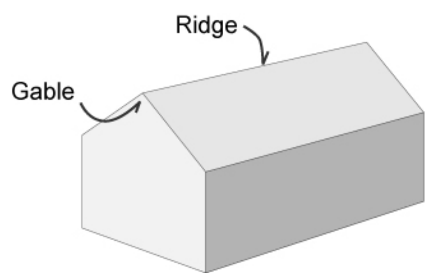


Figure 19: Illustration of Gable Roof

Hip Roof. This roof slopes in four directions such that the end formed by the intersection of slopes is a sloped triangle.

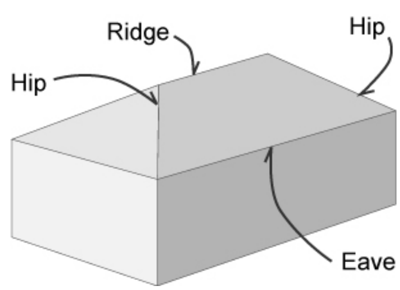


Figure 20: Illustration of Hip Roof

Mansard Roof*.* Like the hip roof, this roof also slopes in four directions, but there is a break in each slope.

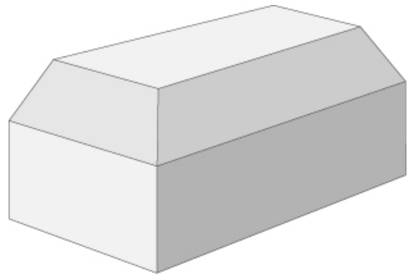


Figure 21: Illustration of Mansard Roof

The roof geometry categories modeled in this Study are as follows:

- **Gable without end bracing** - a gable roof as shown above, with no additional bracing securing the overhanging ends to the main structure.
- **Gable with end bracing -** a gable roof as shown above, with additional bracing securing the overhang to the main structure to resist wind uplift at the corners and top point. For this system to provide additional wind resistance the bracing and the supporting members must be adequate to withstand the wind pressures on the gable end portion of the wall and re-distribute these loads to the lateral load resisting system.
- **Hip** - this shape, as shown above, generally resists wind loads better than unbraced or braced gable roofs.
- **Mansard** or **pyramid** - this shape, as shown above, generally resists wind loads better than unbraced or braced gable roofs.

Roof Covering and Attachments

The roof covering is the material covering the framework of the roof structure to safeguard the roof against the weather.

The roof covering is fixed to the underlying structure by means of a range of fittings and fixtures. The climatic conditions have a marked influence on the performance and durability of roof coverings. Strong winds may blow off roof coverings such as slates, tiles, and asphalt shingles when they are not properly fixed in position. Extreme temperature changes may cause the material to crack and joints to leak, if not properly protected. Atmospheric effects of fog, salt, air, smoke and other gases may result in corrosion of metal roofing if not protected by painting. (Clay tiles, slates, shingles, and built up roof coverings are unaffected by atmospheric action.) The various effects described above can result in poor performance, reduced life, or both.

It is the roof deck to which roof coverings are fastened. The decks are supported on structural members such as girders, trusses, or rigid frames. In the case of shell roofs, the decks serve as a principal supporting member. In some cases, the roof covering and the deck are combined into one unit, such as corrugated roofing. Because of these relationships, both the type of roof covering and the type of roof deck are important features.

The weight of the roof covering affects the design, weight and the cost of both the roof deck and supporting structure or framework. A heavier roof covering requires a stronger supporting structure, which adds to the cost. For example, sheet metal coverings are very lightweight, shingles can be classified as light to medium in weight, and clay tiles and slates are considered to be heavy roof coverings. Supporting structures and roof decks are designed appropriate to the weight of the chosen roof covering.

The roof cover and attachments categories modeled in this Study for residential are as follows:

- **Asphalt shingles** or other types of roof covering, not wind-rated, attached with nails or other methods;
- **Wind-rated** (110 mph or higher wind speed rated) shingles or equivalent roof coverings, attached with nails or other methods. Wind-rated asphalt shingles are assumed to satisfy the requirements of the IRC and IBC codes such as ASTM 3161 or equivalent;[4]
- **Reinforced concrete** with reinforced concrete deck (an integrated system).

Roof Deck and Attachments

The roof deck transfers the roof loads to the underlying trusses or rafters. Damage to the roof deck constitutes a breach of the building envelope and can result in significant building and interior damage. Some of the commonly used roof decks are plywood, precast concrete slabs, reinforced concrete slabs, and light metal.

The method of attachment of the roof deck to the trusses/rafters is also important. There are several common fastener and spacing configurations for non-integrated roof decks (such as those made of plywood or light metal) modeled in this Study:

- **Level A -** Attached with 6d nails and 6 inch spacing for the edge nailing and 12 inch spacing for the field nailing;
- **Level B -** Attached with 8d nails and 6 inch spacing for the edge nailing and 12 inch spacing for the field nailing;
- **Level C -** Attached with 8d nails and 6 inch spacing for the edge nailing and 6 inch spacing for the field nailing.

Roof Anchorage

Unless the roof is integrated with the walls, as in the case of a reinforced concrete roof deck, its trusses are anchored to the walls by fasteners such as nails, screws, clips, or hurricane ties. Roof anchorage is the last layer of defense against wind loads which can uplift the entire roof away from the structure. A depiction of a roof anchored with hurricane ties, the strongest type of fastener, is shown in the figure below.

[4] Standing-seam metal panel roofs are also possible. These roof covers are grouped with wind-rated asphalt shingles in our analysis.

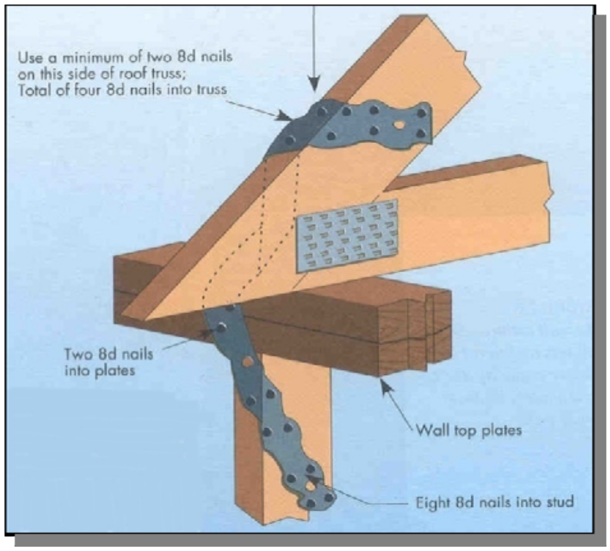


Figure 22: Roof Anchorage with Hurricane Ties

The following categories of roof anchorage for residential buildings are modeled in this Study:

- **Nails** or screws - roof-to-wall connection using nails or screws, such as a typical 3-toe nail connection;
- **Clips -** metal connectors used to attach the structural components of the roof with the supporting members. These connectors have been designed to withstand hurricane loads for design wind speeds up to 110 mph;
- **Hurricane ties** (either single or double wraps) - metal connectors used to attach the structural components of the roof with the supporting members. These connectors have been designed to withstand hurricane loads for design wind speeds higher than 110 mph.

Window Protection

Attaching shutters to all windows in a structure can greatly reduce potential hurricane losses, for several reasons. The effect of wind-blown water leaking into the interior is reduced, as well as the possibility of an interior breach due to debris striking the windows. Shutters can be broadly classified as “non-engineered” or “engineered.” Non-engineered shutters are made to inconsistent specifications – perhaps even consisting of just plywood boards. Engineered shutters are designed in accordance with specific testing requirements by codes. Use of impact resistant glass should provide a similar reduction in vulnerability as the use of engineered shutters. Impact resistant glass specifically refers to glass assemblies that have passed the requirements of the IBC or IRC such as ASTM E1996 or ASTM E1886.

The following categories of window protection for residential buildings are modeled in this study:

- **None** (no protection);

- **Non-engineered** shutters;
- **Engineered** shutters or impact-resistant glass.

Secondary Water Protection

This term refers to materials attached over the roof deck which form a barrier to water entering the interior of the structure once the roof coverings are blown away and the roof deck is exposed or breached. One way of providing a secondary water protection to a plywood deck is to apply a Self-Adhering Modified Bitumen Tape to the plywood panels' joints. This option is modeled in the AIR Individual Risk Model with a simple Yes/No status indicator. Figure 23 shows an example of this feature.

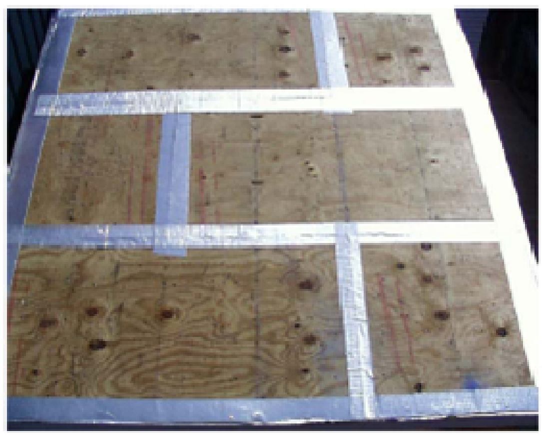


Figure 23: Secondary Water Protection

Garage Doors

Studies show that garage doors are vulnerable as a weak point in the building envelope. We model the presence of garage doors as a potential contributor to increased losses in our insurance benefits tables. We also model the absence of garage doors as a contributor to decreased losses in our insurance benefits tables. In addition, we have considered reinforced garage doors to be equivalent to the absence of garage doors in our insurance benefits analysis. Reinforced garage doors are garage doors with a reinforcement mechanism design to resist hurricane wind pressures, both positive (trying to blow the door inward) and negative (trying to pull the door outward).

Pool Enclosures

Pool enclosures, particularly those attached to main structures, perform very poorly in high winds; they are not only easily destroyed, but form debris which can damage both the structure they are attached to and neighboring structures.

As a result, we model the effect of loss enhancement (as opposed to mitigation) associated with these structures in our analysis of residential buildings.

Feature Definitions and Descriptions – Commercial

Low-, Mid-, and High-Rise Structures

Low-rise wood and masonry commercial structures are generally marginally engineered. They can usually be classified for mitigation analysis using the residential tables. Despite their typical multi-unit residential, small retail, or office occupancies, these structures perform similarly to residential buildings.

Mid-rise structures are generally those with four to seven stories. They have a different set of most relevant construction features, explained below. They are generally less vulnerable and receive greater engineering attention than low-rise structures.

High-rise structures have eight or more stories. These commercial structures, typically occupied as hotels/casinos and office buildings, are well-engineered and subject to fewer opportunities to retrofit mitigation features, but some features are still important in determining relative loss costs for hurricane wind.

Low-rise (residential), and mid-rise plus high-rise commercial, insurance benefits are analyzed and presented in separate sets of tables.

Mid- and High-rise Feature Definitions and Descriptions

Roof Deck

The following categories of roof deck are analyzed in this Study:

- **Wood** - a deck consisting of plywood or other panelized product fastened to the roof structure. Both low-rise and mid-rise wood and masonry structures can have this type of deck. However, wood construction is unlikely to exist for mid- or high-rise buildings.
- **Metal with Insulation** - a roof deck consisting of lapped ribbed metal panels spanning roof structure members. The thickness of the metal, and the depth and spacing of the ribs, will vary depending on the span lengths and loading conditions. Rigid insulation board is attached to the top of the metal deck with mechanical fasteners. All construction types except wood-frame construction may have this type of deck.
- **Metal with Concrete** - a roof deck consisting of lapped ribbed metal panels filled with cast-in-place concrete spanning roof structure members. The thickness of the metal, the depth and spacing of the ribs, and the thickness of concrete will vary depending on the span lengths and loading conditions. All construction types except wood-frame construction may have this type of deck.

- **Reinforced Concrete** - a roof deck consisting of a self supporting cast in place concrete slab with integrated steel reinforcing bars. The deck is temporarily supported with shoring and other formwork until it has gained enough strength to support itself. The thickness of the slab and amount of reinforcing will vary depending on the span lengths and loading conditions. This type of deck is quite common in high-rise buildings.

Secondary Water Protection

Secondary water protection for plywood decks is discussed above and is applicable to commercial structures as well. For metal decks, after the roof covering has peeled off, water enters through the joints. The secondary water protection aims to cover these joints and provide redundant waterproofing of the building.

Opening Protection

Windows and sliding-glass balcony doors can be protected in commercial structures to gain the same types of loss reduction benefits. Again, we divide shutters into **non-engineered** and **engineered** categories.

Glass Percent

Glass is more vulnerable than any other exterior construction material, particularly to breakage as a result of debris impact. Therefore, the proportion of the facade which is glass has a significant impact on loss costs. AIR divides the prevalence of glass into four categories: **less than 5%, 5% to 20%, 20% to 60%, and more than 60%**.

Wall Siding

- **Exterior Insulation and Finish System** - EIFS is a general category of exterior wall cover that consists of a layer of rigid insulation board typically adhered to the wall sheathing, a layer of fiber reinforcement embedded in a cementitious material applied to the insulation and a paint-like topcoat, often textured, that is typically troweled onto the reinforcing layer.
- **Aluminum/Vinyl Siding** - an exterior wall covering consisting of horizontal layers of aluminum or vinyl that are typically designed to imitate the look of wood clapboard. Each layer is mechanically fastened to the wall sheathing.
- **Veneer/Brick Masonry** - an exterior wall cover consisting of brick masonry units connected to the wall of the structure. This masonry veneer is not designed to support the building. For this Study, this type of wall siding is grouped with Aluminum/Vinyl siding and named as “other sidings.”

Glass Type

High-rise buildings typically have a great deal of glass in the facade, and the type of glass used can impact loss costs. We modeled the following glass types for this study:

- **Annealed** – Annealed glass refers to glass that has been 'annealed' or slowly cooled to prevent breakage from typical wear and tear including temperature changes and incidental impact. This process is typical for most glass manufactured today.
- **Tempered** – Tempered glass refers to an annealed glass that has been further exposed to a thermal treatment in order to create additional strength. It is used as a safety glass because of its additional strength and the fact that when broken it shatters into small granular pieces instead of large shards.
- **Laminated** – Laminated glass refers to an assembly of two or more layers of glass separated by a plastic laminate that is bonded to the glass. The laminate will typically hold the assembly together even when the glass has been broken.
- **Impact-Resistant** – Impact resistant glass specifically refers to glass assemblies that have passed the requirements of the IBC or IRC such as ASTM E1996 or ASTM E1886.

Role of Building Codes and IRC 2003 Adoption in Developing Modeled Benefits

Building codes are extremely important to effective mitigation programs because they determine the way that new construction is done, or at least is supposed to be done. Building codes that properly consider the wind loads on the structural components, including potential damage to vulnerable openings of the envelope of the structure, are very important in order to govern the way that new construction and significant renovations are done.

The first prudent step in enhancing regional building codes is the passage of strong statewide building codes for new construction and for significant renovations of existing structures. The next step is for counties and municipalities to agree to adopt at least the IBC and IRC building codes based upon the risk presented within their borders, and to aggressively enforce these or even stronger building codes in overseeing the builders of new homes or significantly renovating damaged structures.

Prior to Hurricane Katrina, the state of Mississippi did not have any statewide mandatory building code for residential construction. Many cities and communities enforced different versions of older codes such as the Standard Building Code. After Katrina, in 2006, the Mississippi Building Code Council requires five coastal counties (Jackson, Harrison, Hancock, Stone and Pearl River) to enforce wind and flood mitigation requirements prescribed by the International Building Code 2003 (IBC) and the International Residential Code 2003 (IRC). However, county boards of supervisors or municipal governing authorities have the right to choose not to be subject to the code requirements imposed under the bill. This decision can significantly impact the damageability of the building stock.

The rest of Mississippi maintains a patchwork of various building codes, and sometimes no codes. However, Mississippi does require that state buildings meet the requirements in the Standard Building Code, and has since the early 1990s. The IBC requires the determination of wind loads per the ASCE 7 standard, and the IBC and IRC also contain several performance and prescriptive requirements regarding roof coverings and wind-borne debris requirements for buildings located in the wind-borne debris regions of hurricane-prone areas.

For new construction, detailed calculations depending on the location of the structure can be performed to assess the defined needs for features such as enhanced roof anchorage, roof covering and roof deck attachment. For example, if the loads indicate that certain features such as clips or hurricane ties would be necessary, this information can be entered in the AIR IRM to obtain the corresponding wind vulnerability of such a structure. In this way, better building code details can be incorporated in the parameters of the Individual Risk Model. It should be noted that many building configurations can satisfy the building code requirements at a given location. See Appendix 2 for an example of the engineering calculations that could be performed to identify the features by location and building characteristics.

For residential properties, AIR believes that there should be significant differences between homes built prior to the adoption of the International Residential Code of 2003 and those built after the IRC 2003 was adopted in the wake of Hurricane Katrina and the devastating 2005 season. As such, the analysis of insurance benefits is split into tables for “existing” construction prior to IRC 2003, and “new” construction since. In practice, structures with a year built of 2007 and later should mostly be subject to the new coastal code.

Importance of Strong Enforcement of Effective Building Codes

A necessary step following the passage and adoption of effective building codes is to aggressively enforce them to ensure compliance by the builders of those structures. Simply having effective building codes in place is not enough to confirm wind loss mitigation. Jurisdictions may put in place a framework of competent building inspectors who ensure that new and significantly renovated structures are actually built in accordance with the adopted building codes.

Some insurers, including the Mississippi Windstorm Underwriting Association, have adopted a specific program to help assess the effectiveness of the inspection and code enforcement efforts of counties and communities and incorporate the results into existing rating plans – ISO’s Building Code Effectiveness Grading Schedule (BCEGS®). BCEGS assesses the building code in effect in a particular community and how the community enforces its building code, with special emphasis on mitigation of losses from natural hazards, such as windstorm and windborne debris. The concept is that municipalities with up-to-date, well-enforced building codes demonstrate better loss experience, and insurance rates should reflect that. This provides an incentive for communities to enforce their building codes rigorously, resulting in benefits of safer buildings, less storm damage, and lower insured losses.

The BCEGS program assigns each municipality a BCEGS grade of 1 (exemplary commitment to building code enforcement) to 10. ISO develops corresponding advisory premium credits and debits that apply to ranges of BCEGS classifications (1-3, 4-7, 8-9, 10). Later, we will discuss how the use of BCEGS factors could lead to overlap between the mitigation algorithm derived in this Study and the existing rating plans in use by insurers, and the required attention by any insurer attempting to “bolt on” a mitigation adjustment, such as the system presented in this Study, to its existing rating plan.

Impact of Year Built on Building Vulnerability

Regional building vulnerability can change over time due to changes in building codes and code enforcement, changes in building construction practices, and structural aging. For example, after Hurricane Hugo (1989) and Hurricane Andrew (1992), there were significant changes in building codes in Florida. These events led to a general awareness of the importance of building mitigation and the proper use of building code requirements in Florida and other hurricane prone regions. Claims data indicates that there is generally a reduction in vulnerability for post-Andrew structures, not only for Florida, but for other threatened states.

Figure 24 shows the reduction in building vulnerability of Mississippi stock over time based on 2004 and 2005 claims data. It is interesting to note that there were no statewide mandated building codes in Mississippi before 2006. Further, it is not known that there were any significant changes in building codes in Mississippi before adoption of the International Residential Codes in 2007. There can be multiple reasons for this significantly lower vulnerability over time in the state.

First, building features might have improved over time even when there were no requirements from building codes. Florida specific claims data has indicated that reduction in the vulnerability over time cannot be solely explained by key building features that are considered to be important for reduction in building vulnerability. Second, general awareness and higher engineering attention after Hurricanes Hugo and Andrew could have led to the proper application of building code requirements in building design and construction, beyond the goal of meeting the requirements for passing the building inspection. Third, newer homes have been subjected to environmental conditions for shorter time periods than older homes and thus have experienced less structural aging. Fourth, improvement of building material and technologies over time could have reduced the vulnerability of buildings. Lastly, there can be other building aspects unknown at this point responsible for reduction in the vulnerability of the newer homes.

Though it is not possible to estimate the impact of each contributing factor from claims data, and there is limited engineering data to estimate the impact of structural aging and other factors, this Study uses a “year-built” factor to capture the changes in vulnerability over time for buildings that are not solely explained by changes in building codes. This data and other AIR research is reflected in the tables of insurance benefits to follow.

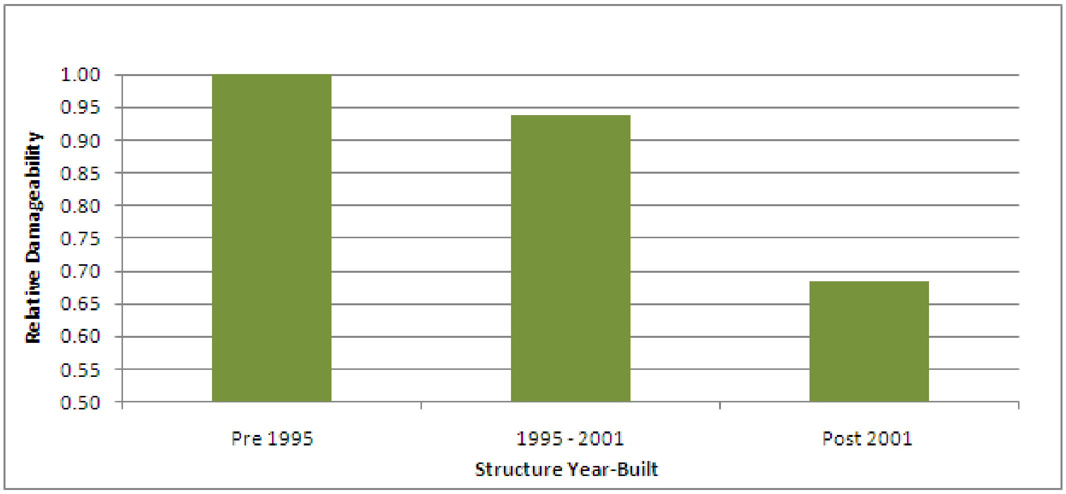


Figure 24: Changes in Mississippi Building Vulnerability Over Time

Other Common or Mississippi-Specific Mitigation Construction Measures

AIR recognizes that other mitigation construction programs also exist, and we have given consideration to two such programs as part of this Study.

Institute for Business and Home Safety (IBHS) "Fortified…for safer living®" Program

One notable mitigation program is the IBHS "Fortified…for safer living program" ("Fortified"). This program offers packages of upgrades that greatly increase a home's resistance to natural perils, such as hurricanes.

The IBHS Fortified program includes packages for new homes, as well as for existing homes that may be retrofit with mitigation features. With respect to the program for existing homes, there are three levels of the designation, and two paths to achieving one of the three levels (Level 1).

We have not explicitly modeled mitigation features that enable a home to achieve the IBHS Fortified designation. However, options that we have modeled in many cases align well with some features of these packages. For example, the "Hurricane Level 1 Option 1" plus the "Hurricane Level 2" IBHS Fortified designation includes the following measures:

Level 1 Option 1 (note that Level 1 is a prerequisite for Level 2)**:**

1. Roof deck attachment is at least equal to the capacity of 8d nails at 6" edge and 6" field installation. In high wind areas (wind speed is greater than 120 mph), the spacing along gable ends and at corners of hip roofs is set to 4" along the edges of the panels and 4" in the field of the panels;
2. Secondary water barrier is equal to what is currently being included in the modeling for this Study;
3. The roof cover is rated for the design wind speeds at the site. This is equivalent to new construction built to International Residential Code (IRC) high-wind requirements;

4. Gable end strengthening of roof deck and overhang attachments.

Level 2:

1. Opening protection is equivalent to "engineered shutters" for glazing and entry doors;
2. Garage doors are able to resist design pressures or are protected by "engineered shutters";
3. Strengthening of gable ends by bracing top and bottom, adding wall studs, and strengthening the connection of the gable end to the wall below;
4. Porches and carports are strengthened so that the anchorage of the overhang meets the design requirements for a continuous load path in new construction.

Corresponding features that we have modeled include the following:

Level 1 Option 1 (note that Level 1 is a prerequisite for Level 2)**:**

1. **Level C** roof deck attachment;
2. **Secondary Water Protection;**
3. **Wind-rated** (110 mph or higher wind speed rated) shingles;
4. **Gable end with bracing** (note that the Gable end with bracing option is comprehensive of bracing measures defined in Level 1 Option 1 and Level 2).

Level 2:

1. **Engineered** shutters;
2. **No garage** (equivalent to reinforced garage doors);
3. **Gable end with bracing** (note that the Gable end with bracing option is comprehensive of bracing measures defined in Level 1 Option 1 and Level 2);
4. **No specific features** in our Study.

Mississippi Windstorm Underwriting Association Mitigation Packages

The MWUA has published mitigation credits based on groups of mitigation packages that can be retrofit to existing structures. We have not explicitly modeled mitigation features that make up these MWUA packages. However, options that we have modeled in many cases align well with some features of these packages. For example, the MWUA "Group A Roof System" package includes the following measures:

Group A Roof System

1. Roof Wall Connection;
2. Collar – Tie / Ridge Board Connection;
3. Hip Rafter Connection;
4. Gable End Bracing;
5. Soffit Protection.

Corresponding features that we have modeled include the following:

Group A Roof System

1. **Hurricane ties;**
2. **No equivalent** in our Study(not applicable in the case of a hip roof);
3. **Hurricane ties** (same as 1 but presumes hip roof);
4. **Gable end with bracing** (in the case of a gable end roof);
5. **No equivalent** in our Study.

Assembly of Exposure and Claims Data

The data we used to model the insurance benefits and feature costs can be broadly divided into three sources:

- Industry-wide Exposure Database – a proprietary AIR database designed for "aggregate" catastrophe modeling when detailed feature data on existing properties is not available;

- Original Databases – various detailed data about the distribution of individual structures in coastal Mississippi with respect to construction type and mitigation features; obtained from several sources in the course of this Study;

- Xactware Cost Databases – proprietary construction cost data from AIR's sister company Xactware, the leading collector of property-level claims data and component-level replacement costs.

The first two databases help us to understand the current status of the building inventory in Mississippi. The Xactware cost database provides information on the cost of different building components for the cost-benefit study.

AIR Industry-wide Exposure Database

AIR's industry-wide exposure database (IED) contains information about general building characteristics such as construction type, occupancy and replacement value. This database covers the entire U.S. building stock. Distributions of building stock by replacement value, construction and occupancy type are estimated from a variety of sources. Underlying AIR's software products, these databases are normally used to develop market share-based or "industry-wide" estimates of damage or insured losses from catastrophic events - either simulated future events, or re-creations of historical events. A comprehensive update of these databases is performed annually, using component data from multiple sources both internal and external to AIR. The IED shows that most single family homes in coastal Mississippi are wood-frame construction. Commercial buildings, however, have a more diverse mix of constructions. Most of the commercial structures are low-rise.

Augmentation of Exposure Data with Original Local Databases

The AIR IED database does not contain detailed building features, such as presence of opening protection, at the level of granularity needed to assess the presence of various mitigation features in the coastal counties of Mississippi. For this reason AIR collected original data local to coastal Mississippi from several other sources.

Building Inventory Survey

AIR subcontracted a survey of building characteristics in Mississippi to the Louisiana State University, led by Dr. Marc Levitan, who also served as a peer reviewer of the IRM and our approach to estimating the insurance benefits in this Study. Since it is not possible to survey each neighborhood in the study area, neighborhoods are pre-selected before performing the survey to obtain comprehensive and unbiased statistics of MS building inventory in the study area as described below.

The survey covers the six southern-most counties of Mississippi: George, Hancock, Harrison, Jackson, Pearl River, and Stone County, and was conducted over a six day period in late July and early August of 2009. The goal of the survey is (1) to maximize the amount of information collected during a six-day period, and (2) to get an unbiased and accurate assessment of the proportion of homes with certain building characteristics and existing mitigation features. This information includes occupancy type (commercial, residential), construction type (wood, masonry, etc.), size of building (stories, square footage), age, roof type, wall type, information on any exterior structures, and any mitigating features present. The survey used an AIR- and LSU-designed neighborhood “drive-by” inspection form as shown in Figure 25 below.

For the survey design, we used the geographic and demographic information about the region covered in this survey. Nearly 80% of the population resides in the three front-line coastal counties: Hancock, Harrison, and Jackson. In terms of size, the total area covered by the inland and coastal counties is roughly the same. The population is the largest in Harrison County, where Biloxi and Gulfport are located. In addition to the demographic information such as number of household, median income and median year-built, AIR also has an exposure database that includes detailed information about the number of risks by construction class and their estimated values by county and ZIP Code.

My Safe Mississippi Building Survey Inspection Form (Neighborhood Type Survey)					
Personnel/Team ID	SMA-JP	Date	7/31/2009	Photo ID(s)	
Neighborhood Location					
State	Mississippi	Lat	30.92408	Neighborhood ID	GR-3
City	Lucedale	Long	-88.59183	Street Intersections	
County	George			Mill St. & Pine St.	
Zip	39452				
Neighborhood Basic Characteristics					
Occupancy (number of buildings)		**Construction (%) ***		**Stories (%)**	
Residential	R (32)	Wood Frame (WF)	100%	1 Story	100%
Commercial- Non Engr		Masonry (URM + RM)	0%	2-3 Story	0%
Commercial- Engr		Reinforced Concrete (RC)	0%	3-7 Story	0%
Mobile Home		Steel (ST)	0%	>7 story	0%
Industrial Construction		Light Metal (LM)	0%		
Neighborhood Construction Quality *		**Avg Building Square Foot (%) ***		**Year-Built (%) ***	
Average		Small (< 1000 sf)	34%	Old Constr. (< 1995)	84%
Good		Medium (1000 - 1500 sf)	50%	Recent Constr. (1995 - 2005)	13%
Poor		Large (1500 - 3000 sf)	16%	New Constr. (Post 2005)	3%
		Very Large (3000 - 5000 sf)	0%		
		Other (> 5000 sf)	0%	* Values in parenthesis are approximate	
Neighborhood Detailed Characteristics					
Roof & Wall Characteristics					
Roof Covering Type (%)		**Roof Geometry (%)**		**Wall Cladding/Siding (%)**	
Asphalt Shingle	97%	Flat	0%	Veneer brick	53%
Wooden Shingle	0%	Hip	19%	Wood shingles	0%
Clay/concrete shingles	0%	Gable End	81%	Clapboards	3%
Light metal panels	3%	Complex	0%	Aluminum/Vinyl siding	44%
Slate	0%	Other	0%	Stone panels	0%
Other	0%			EIFS/Stucco	0%
Unknown	0%			Other	0%
Blue Tarp/Obvious Damage	3%				
Opening Protection				*Foundation type*	
Protection Type (%)		**Exterior Door Type (%)**		**Foundation type (%)**	
No Protection	100%	Single	100%	Slab on Grade	63%
Storm Shutters	0%	Double	0%	Pier (Raised Floor)	38%
		Sliding	0%	Pile	0%
		Unknown	0%		
Glass %		**Garage Door Type**		**Base Floor Height (%)**	
Less than 5%	3%	Single	100%	< 4 ft	100%
5-20%	97%	Double	0%	4 - 8 ft	0%
20-60%	0%			8 - 12 ft	0%
> 60 %	0%			> 12 ft	0%
Exterior Structures					
Pool - Screen enclosure (%)		**Garage (%)**		**Carports - Canopies**	
Yes	0%	Yes	3%	Yes	22%
No/Unknown	100%	No	97%	No	78%
		Unknown	0%	Detached	0%
		Detached	3%		
Comments					

Values do not contribute to 100% total

Figure 25: AIR/LSU Neighborhood Inspection Form

Survey Design

Stratification by county: To collect building information, a random sample of buildings was examined by the survey team. The information collected was specified in an inspection form completed for each building included in the survey. The selection of buildings was based on stratified random sampling with the six counties serving as strata or sub-populations for the study. Stratification by county ensures that all counties are represented in the sample and makes it possible to obtain information on the building stock in the individual counties. This has an advantage in cases where there are marked differences in the building stock between different counties.

Sampling within the counties: Within each county, the selection of buildings to be surveyed was based on cluster sampling. Cluster sampling is often used in applications where a reliable list of individual units, in our case buildings, is not readily available or where it would be very expensive to construct such a list. Also, greater field costs, in particular travel costs, often favors selection of clusters of units as opposed to individual units. In this particular study, the clusters were defined as neighborhoods consisting of 100 or more properties identified using maps of cities or towns within the individual counties. The neighborhoods were further sub-sampled by selecting approximately 50 buildings for closer inspection within each neighborhood.

Prior to selecting the sample, Google Maps and Google Street View were used to study the geography of the counties and to get a feel for how the properties varied from area to area. Using these tools, it was possible to determine, very generally, whether neighborhoods contained newer or older properties and to assess the wealth of the area. The maps also allowed us to estimate the distance to coast of the neighborhoods. Having identified all neighborhoods that could be surveyed, the subsequent sample selection can be summarized as follows:

1) Sample size selection: The number of clusters selected in each county was roughly proportional to the size of the population in these counties. However, some of the inland counties were slightly over-sampled relative to their population sizes to ensure that the number of buildings inspected in these counties was large enough to accurately estimate the building characteristics in these counties.
2) To achieve good spatial coverage, we ensured that all ZIP Codes in the six counties, with the exception of ZIP Codes covering John C. Stennis Space Center and the Keesler Air Force Base as well as other selected ZIP Codes covering limited geographic areas, were represented in the study.
3) Also, to ensure that the selected neighborhoods represented a broad spectrum of buildings, geographical and demographical data are used to classify the neighborhoods based on income level, distance from coast, age of construction, and rural/urban.

A total of 62 neighborhoods were selected, including 8 optional areas to be visited if time permitted. This number was determined based on the likely time required to perform the field work. To help the survey team locate the selected areas, all the neighborhoods were mapped and given an area ID. The maps were provided along with a brief description about the selected neighborhoods.

Results and Discussion

Table 1 provides a summary of the number of buildings assessed by occupancy for each county. The number of single family dwellings surveyed far surpassed the number of buildings of other occupancies, constituting 91% of the buildings inventoried. County-level and study-wide summary information is provided for single family housing units in Table 2. A total of 2,327 single family residential buildings were assessed in the six counties. Table 2 provides per county and study-wide data summaries for single family residences. Wood Frame construction accounted for 99% of the sample.

Table 1: Number of Buildings Assessed Per County for Each Occupancy

County	Residential	Manufactured Housing	Commercial			Industrial
			Engineered	Non-Engineered	Pre-Engineered	
George	77	10	5	25	4	0
Stone	167	6	17	16	5	0
Pearl River	238	36	6	15	5	0
Hancock	452	5	1	13	0	0
Jackson	593	4	9	25	1	1
Harrison	800	3	10	15	3	0
Totals	2327	64	48	109	18	1
% of Total	91%	2%	2%	4%	1%	0%

Table 2: County-wide and Study-wide Building Characteristics for Residential (Single Family) Occupancy

Neighborhood	George	Stone	Pearl River	Hancock	Jackson	Harrison	6 Counties
Number of Buildings	77	167	238	452	593	800	2327
Construction							
Wood Frame (WF)	100%	98%	100%	100%	99%	99%	99%
Masonry (URM + RM)	0%	2%	0%	0%	1%	1%	1%
Reinforced Concrete (RC)	0%	0%	0%	0%	0%	0%	0%
Steel (ST)	0%	0%	0%	0%	0%	0%	0%
Light Metal (LM)	0%	0%	0%	0%	0%	0%	0%
Stories							
1 Story	90%	94%	87%	84%	85%	90%	87%
2-3 Story	10%	6%	13%	15%	15%	10%	13%
4-7 Story	0%	0%	0%	1%	0%	0%	0%
>7 story	0%	0%	0%	0%	0%	0%	0%
Avg Building Square Foot *							
Small (< 1000 sf)	56%	18%	72%	21%	20%	15%	25%
Medium (1000 - 1500 sf)	35%	60%	19%	60%	53%	63%	54%

Neighborhood	George	Stone	Pearl River	Hancock	Jackson	Harrison	6 Counties
Large (1500 - 3000 sf)	9%	21%	8%	19%	26%	21%	20%
Very Large (3000 - 5000 sf)	0%	1%	0%	0%	2%	0%	1%
Other (> 5000 sf)	0%	0%	0%	0%	0%	0%	0%
Year-Built (%) *							
Old Constr. (< 1995)	71%	75%	66%	40%	69%	74%	66%
Recent Constr. (1995 - 2005)	26%	19%	21%	39%	18%	16%	22%
New Constr. (Post 2005)	3%	6%	13%	20%	13%	9%	12%
Roof Covering Type							
Asphalt Shingle	77%	75%	79%	74%	86%	88%	83%
Light metal panels	21%	23%	20%	24%	13%	10%	16%
Wooden Shingle	0%	0%	0%	0%	0%	0%	0%
Clay - concrete shingles	0%	0%	0%	0%	0%	1%	0%
Slate	0%	0%	0%	0%	0%	0%	0%
Other	3%	0%	1%	0%	1%	0%	0%
Unknown	0%	1%	0%	2%	0%	1%	1%
Blue Tarp/Obvious Damage	3%	0%	0%	2%	0%	0%	1%
Roof Geometry							
Gable End	88%	80%	68%	72%	74%	66%	71%
Hip	10%	19%	29%	26%	22%	32%	26%
Flat	0%	1%	0%	0%	0%	0%	0%
Complex	1%	0%	3%	2%	3%	1%	2%
Other	0%	1%	0%	0%	1%	1%	1%
Wall Cladding/Siding							
Horizontal Siding (all)	43%	32%	23%	61%	37%	42%	42%
Veneer brick	36%	46%	53%	22%	51%	51%	45%
Wood shingles	1%	0%	0%	3%	1%	0%	1%
Stone panels	0%	0%	0%	0%	1%	0%	0%
EIFS/Stucco	0%	2%	1%	7%	3%	2%	3%
Other	19%	20%	23%	7%	8%	5%	9%
Glass							
Less than 5%	3%	3%	0%	2%	3%	1%	2%
5-20%	84%	69%	84%	97%	91%	81%	86%
20-60%	13%	28%	16%	1%	6%	18%	12%
> 60 %	0%	0%	0%	0%	0%	0%	0%
Protection Type							
No Protection	100%	100%	100%	98%	99%	99%	99%
Storm Shutters	0%	0%	0%	2%	1%	1%	1%
Exterior Door Type							
Single	97%	93%	98%	81%	94%	96%	93%
Double	1%	2%	2%	7%	4%	2%	3%
Sliding	1%	0%	0%	0%	0%	0%	0%

Neighborhood	George	Stone	Pearl River	Hancock	Jackson	Harrison	6 Counties
Unknown	0%	4%	0%	13%	2%	3%	4%
Garage / Door Type							
Yes	12%	13%	21%	19%	37%	24%	25%
No	88%	76%	79%	78%	60%	73%	72%
Unknown	0%	11%	0%	3%	4%	3%	3%
Single Garage Door	80%	32%	41%	64%	70%	46%	55%
Double Garage Door	20%	68%	59%	36%	29%	54%	45%
GARAGE IS DETACHED	8%	0%	5%	1%	2%	1%	2%
Carports - Canopies							
Yes	23%	30%	40%	31%	22%	21%	26%
No	77%	70%	60%	69%	78%	79%	74%
CARPORT IS DETACHED	0%	6%	3%	2%	4%	2%	3%
Foundation type							
Slab on Grade	53%	60%	62%	37%	70%	65%	60%
Pier (Raised Floor)	47%	40%	38%	46%	26%	26%	33%
Pile	0%	0%	0%	17%	4%	9%	8%
Base Floor Height							
< 4 ft	99%	98%	100%	50%	92%	90%	85%
4 - 8 ft	1%	2%	0%	22%	4%	3%	6%
8 - 12 ft	0%	0%	0%	18%	3%	5%	6%
> 12 ft	0%	0%	0%	9%	1%	2%	3%
Pool - Screen enclosure							
Yes	0%	0%	0%	0%	0%	0%	0%
Unknown/No	100%	100%	100%	100%	100%	100%	100%

Most of the homes (87%) were single story homes, with almost all the rest being two stories. Only a handful of the homes were three stories. Over half of the homes (54%) were medium-sized, (estimated as 1,000-1,500 square feet of living space), with the rest almost evenly split between small and large categories. The estimated age of construction varied somewhat between the different counties, representative of more rapid growth and rebuilding activities in the more coastal and hardest hit counties. The slightly inland counties of George and Stone had a higher percentage of older buildings (71% and 75% respectively), compared to the overall average of 66% for pre-1995 construction for the entire survey. The roofs of single family residences were primarily (71%) gable shape and most of the rest were hip (26%). Asphalt shingles were by far the most common roof covering type (83%), with light metal panels making up the remainder (mainly standing seam, but some occasional corrugated tin roofs are also found). Wall cladding was about evenly split between brick (45%) and horizontal siding (42%), including vinyl, aluminum, fiber cement, and masonite. EIFS/Stucco was used only 3% of the time, and other systems made up 9% of wall cladding, including vertical wood or simulated wood products.

The percentage of glass was primarily in the range of 5-20% (86% of homes). Only about 1% of homes were identified to have engineered storm shutters. It is likely that there is a small percentage of the post-Katrina homes having impact-resistant glazing, but this could not be determined from the windshield survey. Similarly, it is likely that at least a small percentage of homes have non-engineered shutter systems, but these would not have been readily visible either. Over 90% of the homes had single doors, with most of the rest having double doors. Sliding doors were not common, although they may be found more in the back of the homes, which were generally not visible from the driving survey. Only 25% of the homes had garages, where 55% had single doors and 45% had double doors. Another 26% of the homes had carports or canopies. Of the total number of homes, detached garages and carports were present for just 2-3% of the buildings. None of the buildings was observed to have a screened pool enclosure, although the backyard was not visible for many of the structures, so it's possible there could have been a few.

Slab on grade foundations were the most common (60%), with pier and pile/post/column foundations being used 33% and 8% respectively. The height of the first floor above grade was less than 4 ft about 85% of the time, with 6% in both the 4-8 ft and 8-12 ft ranges, and over 12 ft observed 3% of the time. Modest levels of variation exist between the counties on some of the building attributes summarized previously, but usually not too much.

The 'typical' residential building as identified in the insurance benefits tables to follow is representative of the typical Mississippi coastal house. It is a wood frame building, with a gable or hip roof, asphalt roof shingles, and no window protection. A total of 64 manufactured (mobile) homes were assessed in the six counties. About 95% were single wide homes, and only 5% were double wide sections. Approximately 30% of the manufactured homes had some kind of attached structure, such as a covered porch or carport. These features tend to be the first to be damaged in even modest wind speeds, and the damage propagates back to the home itself when these 'add-ons' get blown away.

Commercial buildings exhibited a somewhat broader range of construction types and materials. Only one industrial structure was included in the entire survey, but not useful due to the sample size. There were no strong trends in the quality assessment except perhaps that Jackson County may have had slightly better construction on average, but this data is fairly subjective.

The homogeneity in many important features for mitigation analysis contributes to AIR's decisions regarding the "most common" base structure type used in the insurance benefits tables in later sections, as well as which feature categories should constitute the base situations.

Mississippi Windstorm Underwriting Association

AIR examined both exposure and insurance claims data provided by the Mississippi Windstorm Underwriting Association (MWUA) as a further source of information about the distribution of building features in the coastal counties.

Basic construction type analysis indicated the following distribution by county as shown in Table 3 below.

Table 3: Distribution of MWUA Exposure by Construction Type and County

	Frame			Masonry			
County	Locations	Value - Coverage A	% of Total Coverage A	Locations	Value - Coverage A	% of Total Coverage A	Total Coverage A
George	2,226	$177,244	41.1%	1,947	$253,824	58.9%	$431,068
Hancock	25,050	$3,041,063	61.1%	10,903	$1,937,253	38.9%	$4,978,315
Harrison	62,576	$6,712,600	46.0%	48,444	$7,892,085	54.0%	$14,604,685
Jackson	33,048	$3,208,469	38.3%	35,809	$5,159,301	61.7%	$8,367,770
Pearl River	6,234	$636,393	41.9%	6,342	$883,933	58.1%	$1,520,327
Stone	1,960	$189,430	41.6%	2,037	$266,208	58.4%	$455,638

This reflects all data provided by MWUA with the exception of 2% of locations that had construction codes that could not be mapped

Basic construction type for windpool risks in the Study region is roughly equally split between wood frame and masonry veneer (brick siding over wood frame) structures.

Some, but very limited, information on roof coverings could be gleaned from the data. Most coverings are reported as unknown. The distribution of reported roof cover is shown in Table 4 below.

Table 4: Distribution of Partial MWUA Data - Roof Cover by County

Total Value (A+C) for Policies in Effect as of 06/01/2009 ($000)											
County	Comp Shingle		Metal		Other		Tile		Not Provided		Grand Total
	Value	%	Value	%	Value	%	Value	%	Value	%	
George	$17,490	20%	$4,833	6%	$0	0%	$0	0%	$63,728	74%	$86,051
Hancock	$213,573	17%	$54,350	4%	$110	0%	$150	0%	$1,001,894	79%	$1,270,076
Harrison	$466,724	13%	$42,331	1%	$830	0%	$1,720	0%	$2,953,404	85%	$3,465,009
Jackson	$291,023	14%	$33,492	2%	$35	0%	$201	0%	$1,699,036	84%	$2,023,787
Pearl River	$31,406	10%	$9,654	3%	$0	0%	$152	0%	$283,754	87%	$324,966
Stone	$6,515	9%	$2,545	3%	$15	0%	$0	0%	$66,360	88%	$75,435

Of the records not reported with unknown roof cover, composite shingle is by far the most common feature category at nearly 90% by insured value, though there is no information regarding whether the shingles are wind-rated.

More extensive information was available on the distribution of year built by county. Table 5 shows the results obtainable from the data.

Table 5: Distribution of MWUA Exposure by Year Built and County

Total Value (A+C) by Age							
County	**1994-Prior**		**1995-2006**		**2007-Newer**		**Total**
	Value	**%**	**Value**	**%**	**Value**	**%**	
George	$259,848	61%	$132,972	31%	$32,704	8%	$425,523
Hancock	$2,495,384	51%	$2,036,910	42%	$314,808	6%	$4,847,103
Harrison	$8,931,858	60%	$5,549,522	37%	$470,737	3%	$14,952,117
Jackson	$5,137,585	60%	$3,165,727	37%	$202,537	2%	$8,505,848
Pearl River	$920,343	62%	$529,686	35%	$42,538	3%	$1,492,568
Stone	$262,548	58%	$170,167	37%	$23,262	5%	$455,977

Only a limited amount of new construction likely to the IRC 2003 standard (3% by value) has been completed since Katrina among properties insured by MWUA. In fact, the building stock insured by the windpool is skewed toward pre-1994 structures (60% by value), considered by AIR as the most vulnerable.

Using the LSU and MWUA data, AIR can identify and consolidate our assumptions about the typical building stock in Mississippi.

Xactware Cost Databases

The use of Xactware cost databases to seed the feature cost analysis will be discussed in that section of the Study below.

Modeling of Insurance Benefits

This section discusses the core engineering component of the Study: the modeled insurance benefits for various combinations of building types, construction types, and mitigation features as measured by changes in loss costs (simulated average annual losses per $1,000 unit of exposure).

Modeled Structures

Notional Portfolio Concept

The AIR hurricane model and software can analyze any property data record presented to it, whether or not that record is identifiable and traceable as a structure that actually exists on the ground. For mitigation analysis, we are concerned about the ability to assess all reasonable combinations of features, not only what may be common in a given area. Therefore, it is more efficient, comprehensive, and unbiased to build a “notional” data set of hypothetical properties and apply the model to this experimental data. The reasons for this include:

- Ability to capture all geographical areas and structure types to be used in the analysis, without gaps or concentrations in certain common structure types, or bias toward highly populated areas;
- Ability to ensure all combinations of detailed features are analyzed, whether or not they are common or reflected in any actual insurance data available to the model;
- Ability to sensitivity test the results and relative loss costs to changes in the geographical or construction type distributions.

A notional portfolio is constructed by first defining every combination of possible construction types, heights, and detailed mitigation features to be tested and creating a unique property data record for each combination.

Second, this package of hypothetical properties covering “all the bases” is placed at a defined set of latitude-longitude geocodes which are selected to ensure comprehensive coverage of the Study region.

Third, the entire portfolio is weighted by entering a replacement value by coverage for each record. In some cases, non-uniform weights may be appropriate, but for mitigation analysis relative loss costs are the ultimate statistic of interest. When working with relativities, the replacement value weights will cancel out, so a constant replacement value is selected for each hypothetical property. In this analysis, we have used $100,000 as the structure replacement value.

Attributes of Hypothetical Risks

The model needs information about the geographic location, basic construction and occupancy types, detail regarding individual risk features, and replacement value by coverage to properly assess a property.

Geographic Location

As shown in Figure 26 below, we placed one hypothetical property in many locations using the following considerations:

- Population-weighted centroids of 5-digit ZIP Codes in the Study region;
- Population-weighted centroids of municipalities in the Study region;
- A “grid” of locations spaced near wind speed zone boundaries contained in the Study region, as well as along the coastline.

Consideration of many locations ensures complete geographic coverage of the Study even in sparsely populated areas – some of which may not be sparsely populated in the future.

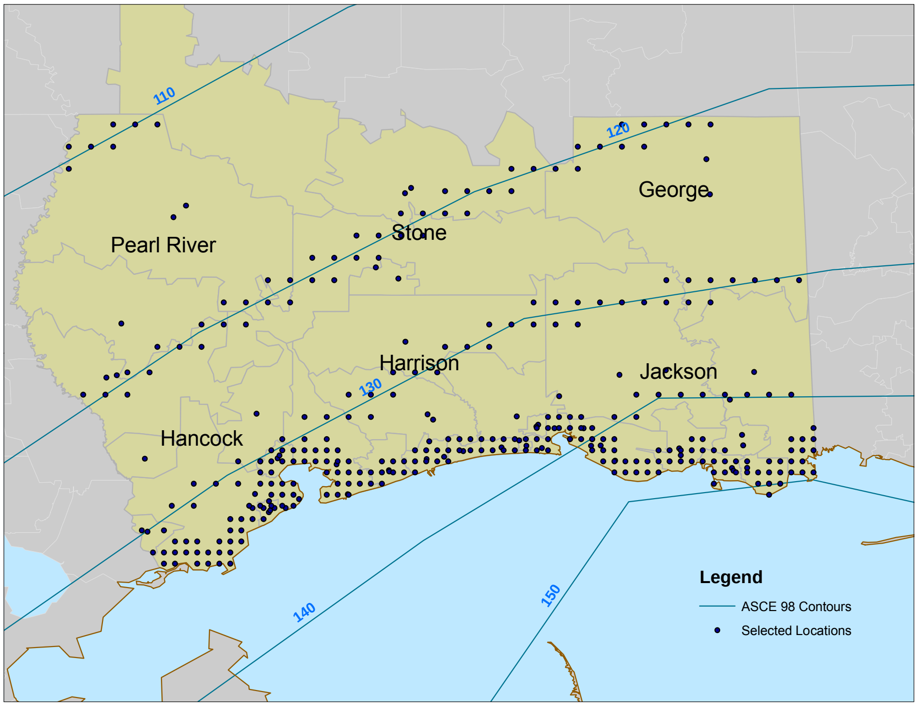


Figure 26: Map of Locations

AIR Construction Types

In the model, structures are fundamentally classified by:

- Construction type;
- Occupancy type;
- Year built;
- Number of stories.

There are many construction and occupancy definitions, some of which apply by peril and by region. For the Study peril and region (hurricane wind in the six coastal Mississippi counties) the most common types of structures and AIR definitions are shown in Table 6 below.

Table 6: Construction Classes, Occupancies, Years, Heights Used in Notional Portfolios

Line of Business	Construction	Occupancy	Height
Residential	Wood Frame/Unreinforced Masonry	Residential/Single Family Home	Low Rise (1-3 Stories)
Commercial	Wood Frame/Unreinforced Masonry Reinforced Masonry Reinforced Concrete/Steel	General Commercial	Low Rise (1-3 Stories) Mid Rise (4 to 7 stories); High Rise (8+ Stories)

Structures in low-, mid-, and high-rise categories were modeled separately to populate the results for the separate relative loss cost tables by height.

Model Version and Adjustments

In order to compute estimates of insurance benefits, AIR modeled the risks as defined above in its CLASIC/2™ software platform, version 11.0, with the AIR Atlantic Tropical Cyclone Model, version 11.0. The benefits were then adjusted to reflect the results of recent research on the impact of mitigation features on building damage. This research has not yet been incorporated into AIR's models, but we plan to incorporate it into the next model version, which we expect to release in the spring of 2010. These adjustments were made in order to produce results reflective of the latest science. Adjusting insurance benefits of mitigation features is reasonable because their impacts on loss costs, while dependent on the nature of the underlying structures, are largely independent of their underlying modeled vulnerabilities.

Actuarial Approach

Insurance Assumptions

It is important to define the assumed type of insurance policy applicable to the analysis, as loss costs depend on the deductible, policy limit, and amounts of insurance in each coverage.

We used a policy with structure coverage only (no amounts of insurance for contents or time element), a 2% hurricane deductible, and a policy limit equal to the replacement value in our analysis. The use of structure coverage only as a basis for the analysis is a simplifying assumption. This was done because different insurers and different insurance products have different proportions of structure, contents, and time element coverages. This can add complications to the computation of insurance benefits if different relative loss costs are developed for different coverages. In an effort to clearly communicate the concepts underlying the insurance benefits computation, we have derived relative loss costs for structure coverages only, and applied those relativities to all coverages. In practice, loss cost relativities may differ for different coverages. The use of the 2% deductible is in accordance with common policy conditions in the Study region and properly makes the layer of loss excess of the deductible the basis of relative loss costs. Insurance-to-value rules at 100% in most residential policy forms make the use of limits equal to replacement value appropriate, and this treatment avoids any overlap between insurance-to-value considerations in existing rating plans and the relative loss costs from the analysis.

Analysis Assumptions

The AIR model offers a variety of analysis options. For this analysis, we chose to use the 10,000-year Standard hurricane catalog, which is parameterized based on the climatology of hurricanes since 1900. We did not adjust the losses for the effects of aggregate demand surge following events, nor include any storm surge losses in our analysis. Insurance benefits therefore consider only the hurricane wind peril. We utilized the average land use/land cover properties over each ZIP Code as the physical properties associated with each hypothetical location used in the analysis.

Choice of Reference Structures

AIR's damage functions are hierarchical and tolerant of incomplete data. Different functions are applied, depending on which attributes are left unknown in the data record, when it is analyzed by the model. For example, different functions would be applied when construction type is unknown, when construction type is known but occupancy type is unknown, and when construction and occupancy type are known but mitigation features are unknown, and finally when all relevant features are coded.

Most insurers capture year built, height, and wall construction type at point of sale, but capture mitigation features less frequently in their source data. The catastrophe modeling, the results of which are a significant influence on reinsurance costs, which in turn influence the base rates to which mitigation modifiers would be applied, is generally done with unknown mitigation features unless these features are captured.

In addition, most insurers currently rate by construction type, but do not rate for specific mitigation features. A mitigation rating plan based on the tables shown below should not be carelessly "bolted on" to an existing overall rating plan without consideration of overlap between current and proposed rating elements during the transition.

There are thus two potential appropriate definitions of a reference structure, given the anticipated use of a mitigation analysis in insurance rating. The loss costs for reference structures are the denominator of the relative loss costs calculated in the insurance benefits tables.

1. An "**unknown**" base structure, e.g. one with known construction types but unknown mitigation features;
2. A "**most common**" base structure, e.g. one with defined construction types and mitigation features selected based on a review of the building stock distribution.

In our tables of results, we have combined elements of both approaches. Some features have been categorized with an “unknown” category, which has a relativity of 1.00. If such relativities are used in rating plans, such a property would get neither a debit nor credit to premium for that feature. Other groups of features have been analyzed with an assumed base case of 1.00 reflecting a specific combination representing the most common structure in the group. In this case, any other feature combination would be debited or credited relative to the most common. The decision on which way to proceed generally involves consideration of whether the feature is used in rating now, the ease of determining the feature category with certainty, and whether the feature should be separated from other features in the benefits analysis.

The practical impact of our approach will become clear in the how-to examples below.

Loss Costs and Relative Loss Costs

Loss costs are the single best statistic to use for a study such as this one, for a number of reasons. First and foremost, loss costs represent the plurality of a typical insurance premium, so it is appropriate to establish insurance rating plans which include mitigation credits and debits based on an analysis of relative loss costs. In other words, the goal is that our results align well with existing rating plans and the underlying cost structures.

In addition, one advantage of the use of loss costs, which are average annual losses per exposure unit, is that they can readily be “rolled up” across geographic locations to produce the various mitigation credits for combinations of building features – in other words, averages are additive. Using another metric to calculate relative credits and debits, based on a loss distribution percentile or dispersion measure such as the 100-year (1% exceedance probability) loss or the standard deviation of losses, would make the process of combining results across locations or features far more difficult.

Development of Loss Relativities

The loss cost for a given combination of mitigation features is defined as the amount of the average annual losses over all years simulated in the 10,000-year catalog, divided by the notional exposure value in thousands. The relative loss cost, which when reduced by 1.00 is the mitigation credit or debit, is the ratio of the loss cost for the combination in question to the loss cost for the base structure as defined by AIR for the analysis.

Non-Linearity of Relativities

As discussed above, the individual risk model does not operate linearly. Certain combinations of features (e.g. engineered shutters paired with wind-rated roof cover) may show higher or lower credits or debits when utilized together as a group than if the individual features were each modeled separately. It is not sufficient to simply model each one of the feature categories for each building component separately and combine the results with mathematical operations. In this study, all possible combinations of features have been explicitly modeled, in order to ensure that the impact of features which work in combination with one another are modeled properly.

The practical effect is that the mitigation credit/debit algorithm for a given property cannot be totally separated into a series of multiplicative or additive factors which apply independently. In contrast, the tables of benefits are sometimes complex because several features must be considered at once.

Results of Insurance Benefits Analysis

The primary products of the insurance benefits analysis are relative loss costs. This is the information that is reflected in the results sets below.

We have separated the analysis of insurance benefits into four main results sets:

- Residential, “Existing” construction built before adoption of the International Code Council (ICC) codes;
- Residential, “New” (Post-ICC) construction built to ICC codes;
- Commercial, Low-rise construction (1 to 3 stories, similar to residential);
- Commercial, Mid- and high-rise construction (4 or more stories).

Residential “Existing” Construction

Table 7 presents the relative loss costs for feasible combinations of certain detailed features for residential construction built before ICC code adoption. The “most common” base building used as the denominator (1.00 relative loss cost) is shaded. The base selection has been made after analysis of building stock data collected for this Study as well as AIR’s existing data and engineering and actuarial judgment. A “most common” approach is used because existing building techniques make some feature combinations much more prevalent than others.

Table 7: Relative Loss Costs for Residential Existing Construction

Existing Construction OCCUPANCY: SINGLE FAMILY HOME					ROOF GEOMETRY								
					GABLE END WITHOUT BRACING			GABLE END WITH BRACING			HIP		
					OPENING PROTECTION			OPENING PROTECTION			OPENING PROTECTION		
CONSTRUCTION TYPE	SECONDARY WATER PROTECTION	ROOF COVER & ATTACHMENT	ROOF DECK TYPE & ATTACHMENT	ROOF ANCHORAGE	NONE	Non-Engineered Shutter	Engineered Shutter	NONE	Non-Engineered Shutter	Engineered Shutter	NONE	Non-Engineered Shutter	Engineered Shutter
Wood Frame - Unreinforced Masonry	NO	NON-WIND RATED COVER	PLYWOOD + Level A Attachment	NAILS / SCREWS	1.19	1.03	0.90	1.14	0.99	0.85	1.14	0.98	0.83
				CLIPS	1.13	0.99	0.86	1.10	0.94	0.80	1.09	0.93	0.78
				HURRICANE TIES	1.11	0.97	0.84	1.08	0.92	0.78	1.07	0.91	0.76
			PLYWOOD + Level B Attachment	NAILS / SCREWS	1.00	0.86	0.73	1.00	0.83	0.69	1.00	0.83	0.68
				CLIPS	0.95	0.80	0.66	0.93	0.76	0.61	0.93	0.75	0.60
				HURRICANE TIES	0.93	0.77	0.64	0.91	0.73	0.59	0.91	0.72	0.57
			PLYWOOD + Level C Attachment	NAILS / SCREWS	0.95	0.81	0.68	0.95	0.79	0.65	0.95	0.78	0.64
				CLIPS	0.89	0.74	0.62	0.88	0.71	0.57	0.88	0.70	0.56
				HURRICANE TIES	0.87	0.72	0.59	0.86	0.69	0.54	0.85	0.67	0.53
		110 MPH WIND RATED COVER	PLYWOOD + Level A Attachment	NAILS / SCREWS	1.06	0.92	0.80	1.04	0.89	0.76	1.03	0.88	0.75
				CLIPS	1.01	0.88	0.76	0.99	0.84	0.71	0.99	0.83	0.69
				HURRICANE TIES	1.00	0.87	0.75	0.97	0.82	0.69	0.97	0.81	0.67
			PLYWOOD + Level B Attachment	NAILS / SCREWS	0.86	0.72	0.60	0.87	0.71	0.58	0.87	0.71	0.57
				CLIPS	0.80	0.66	0.54	0.80	0.63	0.50	0.80	0.63	0.48
				HURRICANE TIES	0.78	0.64	0.51	0.78	0.61	0.47	0.78	0.60	0.45
			PLYWOOD + Level C Attachment	NAILS / SCREWS	0.81	0.67	0.56	0.82	0.66	0.54	0.82	0.66	0.53
				CLIPS	0.75	0.61	0.49	0.75	0.58	0.45	0.75	0.58	0.44
				HURRICANE TIES	0.73	0.58	0.46	0.73	0.56	0.42	0.73	0.55	0.41
	YES	NON-WIND RATED COVER	PLYWOOD + Level A Attachment	NAILS / SCREWS	1.12	0.98	0.86	1.09	0.95	0.81	1.09	0.93	0.79
				CLIPS	1.08	0.94	0.82	1.05	0.90	0.76	1.04	0.88	0.74
				HURRICANE TIES	1.06	0.93	0.80	1.03	0.88	0.74	1.02	0.86	0.72
			PLYWOOD + Level B Attachment	NAILS / SCREWS	0.95	0.81	0.69	0.95	0.79	0.65	0.95	0.78	0.64
				CLIPS	0.90	0.75	0.63	0.89	0.72	0.58	0.88	0.70	0.56
				HURRICANE TIES	0.88	0.73	0.60	0.86	0.69	0.55	0.86	0.68	0.53
			PLYWOOD + Level C Attachment	NAILS / SCREWS	0.90	0.77	0.65	0.90	0.75	0.61	0.90	0.74	0.60
				CLIPS	0.85	0.70	0.58	0.84	0.67	0.53	0.83	0.66	0.52
				HURRICANE TIES	0.83	0.68	0.56	0.81	0.64	0.51	0.81	0.63	0.49
		110 MPH WIND RATED COVER	PLYWOOD + Level A Attachment	NAILS / SCREWS	1.01	0.88	0.76	0.99	0.85	0.72	0.99	0.84	0.71
				CLIPS	0.97	0.84	0.72	0.95	0.80	0.67	0.94	0.79	0.66
				HURRICANE TIES	0.95	0.83	0.71	0.93	0.78	0.65	0.92	0.77	0.64
			PLYWOOD + Level B Attachment	NAILS / SCREWS	0.82	0.68	0.57	0.83	0.67	0.54	0.83	0.67	0.54
				CLIPS	0.76	0.62	0.50	0.76	0.59	0.46	0.76	0.59	0.45
				HURRICANE TIES	0.74	0.60	0.48	0.73	0.57	0.43	0.73	0.56	0.42
			PLYWOOD + Level C Attachment	NAILS / SCREWS	0.77	0.64	0.53	0.78	0.63	0.50	0.78	0.62	0.50
				CLIPS	0.71	0.57	0.46	0.71	0.55	0.42	0.71	0.54	0.41
				HURRICANE TIES	0.69	0.55	0.43	0.68	0.52	0.39	0.68	0.51	0.38

		NONE	Non-Engineered Shutter	Engineered Shutter
Reinforced Conrete	Reinforced Concrete Slab	1.00	0.75	0.55

Wood frame and unreinforced masonry[5] structures can be analyzed using the same table, as insurers typically now rate using a "construction type factor" designed to distinguish the basic differences in wall construction. Using the same mitigation credits/debits for each type, with no explicit credit/debit for wall construction, avoids "actuarial overlap" between existing rating plans and mitigation adjustments.

Here, we see that many aspects of the roof system, together with window protection, operate in conjunction to produce a given level of hurricane wind loss mitigation. Roof cover (with attachment style), roof deck attachment, roof anchorage, and secondary water protection applied under the roof work in concert against a base which depends on roof geometry. The effect of window protection is applied simultaneously with the roof system components to produce a relativity. Note that impact-resistant glass is equivalent to engineered shutters, so relative loss costs for this feature can be drawn from the 'Engineered Shutter' entries in the tables.

[5] Insurance manuals often refer to "joisted masonry," meaning unreinforced masonry with a wood or other combustible roof deck.

In contrast to other roof system features, year built, roof geometry, and presence of attached features like garage doors and pool enclosures are separated as multipliers which apply independently in sequence with the relativity from Table 7. The multipliers or for each feature and category are shown in Table 8.

Table 8: Multipliers for Residential Existing Construction

Construction Multiplier	
Wood Frame / Unreinforced Masonry	1.00
Reinforced Masonry	0.90
Reinforced Concrete	0.55
Year-Built Multipliers	
Unknown	1.00
Pre 1995	1.05
1995-2006	0.90
Post 2006	0.80
Roof Geometry Multipliers	
Unknown	1.00
Gable end without bracing	1.12
Gable end with bracing	0.95
Hip	0.90
Garage Door Multipliers	
Unknown	1.00
Garage	1.05
No Garage	0.98
Pool Enclosure Multipliers	
No Pool Enclosure	1.00
Pool Enclosure	1.15

Note: The reinforced concrete multiplier applies only for reinforced concrete structures with reinforced concrete roof slabs

Roof geometry is considered separately as a multiplier for two reasons:

- Unlike other aspects of the roof system, it is difficult to retrofit even when replacing the roof cover and deck;
- The distribution of roof geometry for existing construction is more evenly split than that of most other features, making it more difficult to establish a single “most common” base.

However, since hip, mansard, and pyramid roof shapes exhibit similar vulnerability, they have been combined in Table 7.

Year built faces similar considerations – it is a fixed value not subject to retrofit, and there is a broad distribution of the age of structures in coastal Mississippi. It does not make sense and would be unwieldy to incorporate many year built ranges in existing construction, duplicating Table 7 many times. However, there is a "bright line" reflecting IRC 2003 building code changes in new construction, such that a separate table should be used. As discussed earlier, the year-built multiplier here captures the changes in building vulnerability that is reflected in the building codes. The year-built factor penalizes the vulnerability for buildings built prior to 1995, but provides credits for buildings built after 1994. This factor is applied in addition to the credits or debits for building features, as shown below in a sample calculation.

Since insurers often use an "age of home" credit in underwriting or rating plans now, it is again important to consider the overlap between the use of year-built in mitigation credits or debits and the potential duplicative use of the same element in existing classification plans. Insurers may wish to modify current age of home credits and debits when any rating plan adjustments for mitigation features are bolted on to the overall algorithm.

Garages and pool enclosures are optional, and pool enclosures are not overly common in coastal Mississippi residential construction, so it also makes sense to separate them as multipliers. Pool enclosures in particular are a significantly loss-enhancing rather than loss-mitigating feature, as was observed in Hurricane Wilma in 2005[6]. It is appropriate to apply a "lack of mitigation penalty" to homes with these additional structures. Note that reinforced garage doors are equivalent to having no garage, so a multiplier for this feature can be drawn from the 'No Garage" entries in the tables.

Table 7 and Table 8 together are used to find the overall insurance benefit (mitigation credit) applicable to a particular residential structure of pre-2007 construction, as follows:

	Construction Multiplier (Table 8)
x	**Year Built multiplier (Table 8)**
x	**Roof Geometry multiplier (Table 8)**
x	**Roof system and window protection multiplier (Table 7)**
x	**Garage multiplier (Table 8)**
x	**Pool enclosure multiplier (Table 8)**
=	**Relative loss cost to base building for construction, year built, and roof geometry**
-	**Unity (1.00)**
=	**Mitigation credit (< 0) or debit (> 0)**

In a typical rating formula, the mitigation credit or debit is applied to the hurricane portion of the base premium to yield a post-mitigation hurricane premium. This is appropriate if and only if the existing rating algorithm is adjusted for any overlap between features considered within the mitigation calculation and similar consideration of the same features in other parts of the formula. Further, the adjusted hurricane premium must be combined with the remaining steps in the rating formula – such as calculations of premiums for other perils, premiums for optional coverages and

[6] Some claims analyses found that nearly 30% of all losses incurred in Wilma were for residential pool enclosures.

endorsements, and flat policy fees – to arrive at the final policy premium after adjustment for mitigation.

A key consequence of this actuarial necessity is that consumers tend to view the "premium credits" as the ratio of total premium dollars (e.g. declarations page premium) paid after and before mitigation is considered. Insurers and their actuaries, on the other hand, tend to speak of "credits" as individual modification factors to a portion of the premium. The central messaging challenge in explaining the actuarial benefit of mitigation to consumers is to carefully draw the distinction between the proportion of hurricane wind losses reduced and its dampened effect on the proportion of final premium dollars eliminated. This challenge is exacerbated by the fact that insurers use a wide variety of formulas, factors, and endorsements to determine the non-hurricane premium, making it difficult to select a "one size fits all" scenario for outreach purposes. Nonetheless, examples below are intended to assist in this effort.

How to Apply Benefits Analysis as Mitigation Credits/Debits: Worked Example

A couple of examples of applying these calculations to a typical insurance request may help integrate the various components of the analysis.

Mitigation Example 1 - Suppose an insurer models a home in which the original roof was recently replaced, with the following attributes:

- Construction type of unreinforced masonry;
- Year built of 1990;
- Roof geometry of hip;
- Roof cover of wind-rated shingles (110 mph rated cover);
- Roof deck attachment of Level B (plywood with 8d nails @ 6"/12" spacing);
- Roof anchorage of nails/screws;
- No secondary water protection;
- No window protection;
- Two-car garage with standard door;
- No pool enclosure.

Suppose further that the replacement value is $150,000 and the average annual loss is determined based on modeling with unknown features to be $**1,000**, including coverages for building, contents, and time element. Using the tables and the algorithm above, we get a relative loss cost of

	1.05 (Year built), from Table 8
x	0.90 (Hip roof), from Table 8
x	0.87 (No SWP, wind-rated roof cover, Level B roof deck, nailed anchorage, no shutters, for a masonry home with a hip roof), from Table 7
x	1.05 (Double standard garage door), from Table 8
x	1.00 (No pool enclosure), from Table 8
=	0.86 (relative loss cost rounded to two decimal places)
-	1.00

= <0.14> or a 14% mitigation credit

Now the key question is: to what portion of the original policy premium should the 14% reduction apply? The credit of 14% could be viewed as a reduction in average annual losses of (0.14) x ($1,000) or about $140 in possible hurricane premium savings. Depending on the insurer's overall rating plan, this could be considered a good opening estimate of the actuarially indicated reduction to policy premium dollars. But in a practical rating formula, hurricane AALs in dollars rarely appear as a base. Instead, we must find some way of adjusting the 14% down to a percent that can be applied to a broader base premium developed to cover not only hurricane AALs, but non-hurricane losses, underwriting expenses, and reinsurance costs as well.

The problem can be depicted as requiring answers to several separate questions:

- How much "grossing up" of hurricane losses is necessary for fixed and variable underwriting expenses and reinsurance costs to convert modeled losses to hurricane premium?
- How much will hurricane reinsurance costs decline if modeled losses decline? In particular, will they decline not at all, in proportion to the average annual losses, or in some other fashion?
- How much "ballast" in the form of premiums for other perils, such as theft, fire, and lightning, to which mitigation credits should not apply, is in the base premium?

A realistic illustration of the potential premium savings to the consumer requires assumptions about these answers as well as a number of others:

- The hurricane portion of the premium is separated in the formula;
- Similar rating factors apply to the hurricane and other perils;
- The mitigation credits apply to all coverages, not just structure (Coverage A in a homeowners policy) within the package policy;
- Only some of the hurricane losses are reinsured, and the reinsurers charge a risk load – expressed as a multiple of the average annual loss – on the portion of hurricane losses they expect to insure.

An example showing the impact of mitigation credits using a simplified ratemaking formula is shown below:

Table 9: Impact of Mitigation Credits

Item	Source	Description	Amount
[1]	Assumed	Structure Insured Value	150,000
[2]	Assumed	Expected Gross Annual Hurricane Losses	1,000
[3]	Report	Mitigation Credit from Tables 7 and 8	14.0%
[4]	Assumed	Expected Gross Annual Non-Hurricane Losses	250
[5]	Assumed	Reinsurance Cost Risk Load Multiple	1.50
[6]	[2] x [5]	Net (non-loss portion of) Reinsurance Costs	1,500
[7]	Assumed	Fixed Underwriting Expenses per Policy	100
[8]	Assumed	Commission, Tax, and Acquisition Expense Ratio	15.0%
[9]	Assumed	Profit Allowance Ratio	3.0%
[10]	([2]+[4]+[6]+[7])/(1-[8]-[9])	Fair Premium Without Mitigation Credit	3,476
[11]	([2]x(1-[3])+[4]+[6]+[7])/(1-[8]-[9])	Fair Premium With Mitigation Credit Applied Only to AAL	3,305
[12]	(([2]+[6])x(1-[3])+[4]+[7])/(1-[8]-[9])	Fair Premium With Mitigation Credit Applied to Entire Hurricane Premium	3,049
[13]	1-[11]/[10]	Declarations Page "Premium Credit" - Only AAL Adjusted	4.9%
[14]	1-[12]/[10]	Declarations Page "Premium Credit" - Entire Hurricane Premium Adjusted	12.3%

In this example, we must assume values for non-hurricane losses, expenses, and reinsurance cost relationships. While AIR reviewed recent rate filings in Mississippi to ensure that the assumed values are within a reasonable actuarial range, these values do not represent our opinions or estimates for any insurer, and are not important except as placeholders to enable the calculation.

A standard actuarial formula is used to get the premium before and after mitigation credits. For a $150,000 structure close to the coast in Mississippi, with the assumed parameters for non-hurricane losses, net reinsurance costs, and expenses, the fair premium before applying the mitigation credit is derived by adding up the hurricane AAL, the expected gross annual non-hurricane losses, the reinsurance cost load, and the fixed underwriting expenses, then grossing up for “variable” expenses by dividing by one minus the sum of all variable expense ratios. Variable expenses, such as agent commissions and taxes, are those directly charged to each policy as a percent of premium rather than fixed aggregate dollar amounts allocated to policy. This yields a premium of $3,476 before applying the mitigation credit.

Now we arrive at an important implicit actuarial assumption, which is whether net reinsurance costs (in excess of expected ceded losses) will be fully reduced in proportion to the mitigated gross losses, not reduced at all, or something in between. Said differently, does the reinsurer provide the same degree of “credit” in their market price as the model indicates for mitigated property? Empirical evidence indicates a wide range of reinsurer reactions to modeled loss data which take the detailed property-level mitigation features into account, from total ignorance of the change in modeled losses versus an “unknown” set of features, to nearly full consideration of the modeled loss reductions due to mitigation. Since reinsurance is typically “syndicated” by brokers among many market participants, it is very difficult to make a blanket assumption about the degree of reduction in reinsurance costs when gross losses are modeled with mitigation features included. Therefore, we have simply presented the two extremes in our example.

The fair premium with the mitigation credit applied only to the AAL (e.g. no reinsurance credit) is derived by multiplying the AAL by one minus the amount of the credit, adding this modified AAL to the expected gross annual non-hurricane losses, the reinsurance cost load, and the fixed underwriting expenses, and grossing up for variable expenses as before. This yields a premium of $3,305. The 14% mitigation credit yields reduction of 4.9% to the premium seen by the consumer on the policy declarations page.

The fair premium with the mitigation credit applied to the AAL and the reinsurance risk load (e.g. "full credit" from the reinsurer for mitigation) is derived by multiplying the sum of the AAL and the reinsurance risk load by one minus the amount of the credit, adding this to the expected gross annual non-hurricane losses, the reinsurance cost load, and the fixed underwriting expenses, and grossing up for variable expenses as before. This yields a premium of $3,049. The 14% mitigation credit now yields reduction of 12.3% to the "dec page" total premium.

To recap, the reasons that the premium reduction differs from the mitigation credit are as follows:

- The multi-peril property policy covers more than just hurricanes;
- The premium must reflect not only loss costs, but expenses and other risk sharing costs required to ensure claims-paying ability after storms;
- Reinsurance costs for mitigated properties may not be reduced fully in proportion to expected hurricane losses.

The practical takeaway: as different insurers incorporate mitigation into existing rating plans, final premium reductions for consumers will vary even if insurers use the same mitigation credits as a starting point and maintain actuarially sound rates.

Mitigation Example 2 – Just as illustrative might be a premium calculation example for the same homeowner, had the choice been to not do anything to strengthen the unmitigated home when the roof was replaced.

	1.05 (Year built), from Table 8
x	0.90 (Hip roof), from Table 8
x	1.14 (No SWP, non-wind-rated roof cover, Level A roof deck, nailed anchorage, no shutters, for a masonry home with a hip roof), from Table 7
x	1.05 (Double standard garage door), from Table 8
x	1.00 (No pool enclosure), from Table 8
=	1.13 (relative loss cost rounded to two decimal places)
-	1.00
=	0.13 or a 13% mitigation debit

In this case, the impact of the debit on the total premium is as follows:

Table 10: Impact of Debit on Total Premium

Item	Source	Description	Amount
[1]	Assumed	Structure Insured Value	150,000
[2]	Assumed	Expected Gross Annual Hurricane Losses	1,000
[3]	Report	Mitigation Credit from Tables 7 and 8	(13.0%)
[4]	Assumed	Expected Gross Annual Non-Hurricane Losses	250
[5]	Assumed	Reinsurance Cost Risk Load Multiple	1.50
[6]	[2] x [5]	Net (non-loss portion of) Reinsurance Costs	1,500
[7]	Assumed	Fixed Underwriting Expenses per Policy	100
[8]	Assumed	Commission, Tax, and Acquisition Expense Ratio	15.0%
[9]	Assumed	Profit Allowance Ratio	3.0%
[10]	([2]+[4]+[6]+[7])/(1-[8]-[9])	Fair Premium Without Mitigation Credit	3,476
[11]	([2]x(1-[3])+[4]+[6]+[7])/(1-[8]-[9])	Fair Premium With Mitigation Credit Applied Only to AAL	3,634
[12]	(([2]+[6])x(1-[3])+[4]+[7])/(1-[8]-[9])	Fair Premium With Mitigation Credit Applied to Entire Hurricane Premium	3,872
[13]	1-[11]/[10]	Declarations Page "Premium Credit" - Only AAL Adjusted	(4.6%)
[14]	1-[12]/[10]	Declarations Page "Premium Credit" - Entire Hurricane Premium Adjusted	(11.4%)

This reflects the fact that it would remain a more vulnerable structure to hurricane damage than one with “unknown” mitigation features.

Residential “New” Construction

Table 11 shows the relative loss costs for “new” construction to the IRC 2003 (year built 2007 and newer). This table is structured differently than Table 7, primarily because certain combinations of features are either very common, or outright prescribed or proscribed, under the new code. In particular, the roof cover and roof deck materials and attachments, along with roof anchorage, can be analyzed in a smaller number of feasible combinations. Certain combinations which are possible but unlikely under the code are shaded in gray, and the “most common” base properties for calculation of credits and debits are shaded.

Another reason the table for new construction is different is due to the consideration of “wind speed zones” defined by ASCE in the IRC 2003 code. An approximate way to look up wind speed zone could be based on the 5-digit ZIP Code of the property in question. Note that this is simply a device to assist in modeling and rating and not a prescription of recommended design wind speeds, which is beyond the scope of this Study.

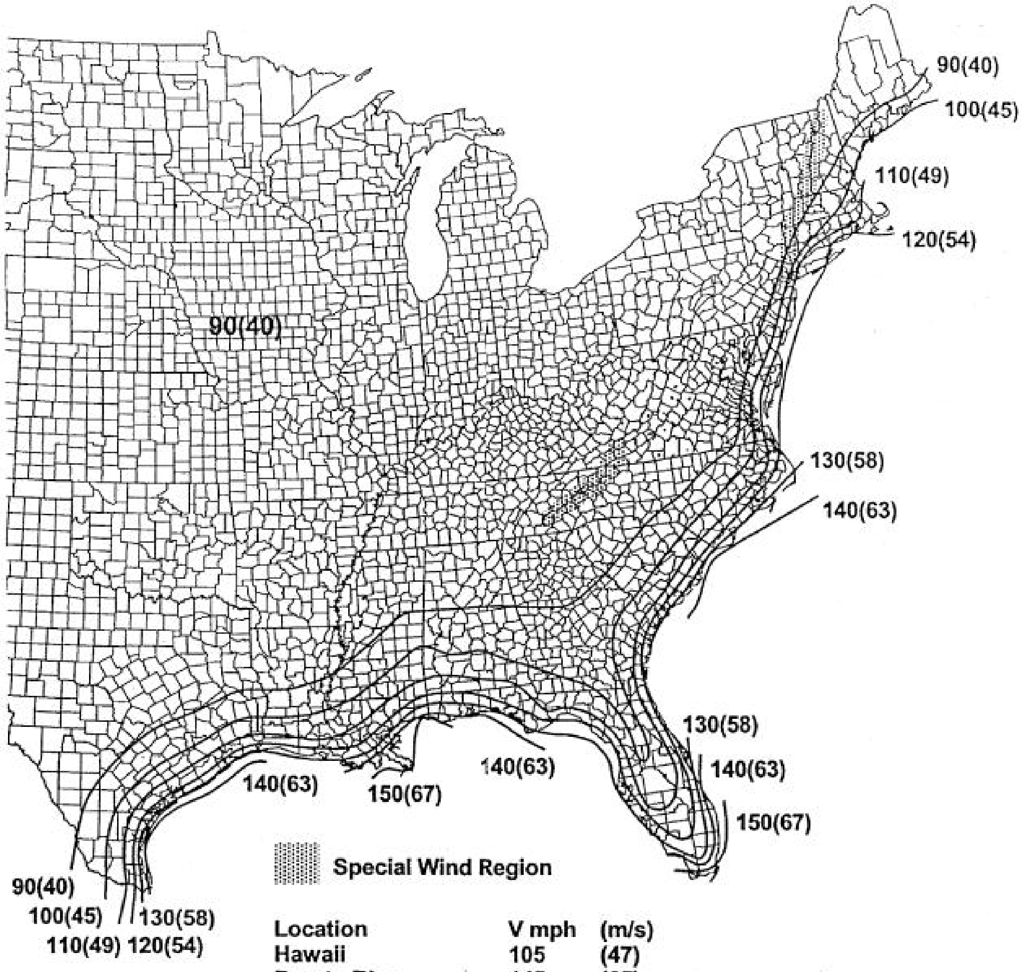
The algorithm for existing construction is also applicable to new construction. All of the multipliers are used in the same fashion and with the same values. However, the roof system and window protection relativities are looked up - according to wind speed design zone - in the new construction rather than existing construction table. Also, a preliminary step of determining the wind speed zone of the structure from either its ZIP Code or another means must be completed so that the right section of Table 11 can be used.

Table 11: Relative Loss Costs for Residential New (IRC 2003) Construction

NEW SINGLE FAMILY HOME IRC/IBC 2003					ROOF GEOMETRY								
					GABLE END WITHOUT BRACING			GABLE END WITH BRACING			HIP		
					OPENING PROTECTION			OPENING PROTECTION			OPENING PROTECTION		
Wind Speed Zone	SECONDARY WATER PROTECTION	ROOF COVER & ATTACHMENT	ROOF DECK TYPE & ATTACHMENT	ROOF ANCHORAGE	NONE	Non-Engineered Shutter	Engineered Shutter	NONE	Non-Engineered Shutter	Engineered Shutter	NONE	Non-Engineered Shutter	Engineered Shutter
90 - 100 mph	No	Non-Wind Rated Roof Cover	PLYWOOD + Level B Attachment	Clips	0.95	0.80	0.66	0.93	0.76	0.61	0.93	0.75	0.60
	Yes	Non-Wind Rated Roof Cover	PLYWOOD + Level B Attachment	Clips	0.90	0.75	0.63	0.89	0.72	0.58	0.88	0.70	0.56
100 - 110 mph	No	Non-Wind Rated Roof Cover	PLYWOOD + Level B Attachment	Clips	0.95	0.80	0.66	0.93	0.76	0.61	0.93	0.75	0.60
	Yes	Non-Wind Rated Roof Cover	PLYWOOD + Level B Attachment	Clips	0.90	0.75	0.63	0.89	0.72	0.58	0.88	0.70	0.56
110 - 120 mph	No	110 MPH WIND RATED COVER	PLYWOOD + Level C Attachment	Hurricane Ties	0.73	0.58	0.46	0.73	0.56	0.42	0.73	0.55	0.41
	Yes	110 MPH WIND RATED COVER	PLYWOOD + Level C Attachment	Hurricane Ties	0.69	0.55	0.43	0.68	0.52	0.39	0.68	0.51	0.38
120 - 140 mph	No	110 MPH WIND RATED COVER	PLYWOOD + Level C Attachment	Hurricane Ties	0.73	0.58	0.46	0.73	0.56	0.42	0.73	0.55	0.41
	Yes	110 MPH WIND RATED COVER	PLYWOOD + Level C Attachment	Hurricane Ties	0.69	0.55	0.43	0.68	0.52	0.39	0.68	0.51	0.38

Notes
1) Relativities in this table are with respect to the same base building as in Table 7: Relative Loss Costs for Residential Existing Construction
2) Structure Year-built multiplier is not included in the relativities of this table and should be applied in calculation of final relativity

Design wind speeds for a given location can be obtained from the ASCE 7 wind speed map. The design wind speed should also be checked with the local authorities since they can also prescribe a different wind speed to use in the design of the structure.



Location	V mph	(m/s)
Hawaii	105	(47)
Puerto Rico	145	(65)
Guam	170	(76)
Virgin Islands	145	(65)
American Samoa	125	(56)

Notes:
1. Values are nominal design 3-second gust wind speeds in miles per hour (m/s) at 33 ft (10 m) above ground for Exposure C category.
2. Linear interpolation between wind contours is permitted.
3. Islands and coastal areas outside the last contour shall use the last wind speed contour of the coastal area.
4. Mountainous terrain, gorges, ocean promontories, and special wind regions shall be examined for unusual wind conditions.

Figure 27: ASCE Wind Map

Notes

1) Exposure C refers to open terrain.

Commercial low-rise construction

Low-rise commercial buildings have similar construction as single family homes. Loss relativities for low-rise commercial are very similar to single family homes. As a result, the credits referenced in Table 7 also apply for structures of this type for feasible combinations of certain detailed features for commercial construction built before adoption of ICC codes. There is limited information about detailed building features for commercial buildings from our building inventory survey. The "most common" commercial building used as the denominator (1.00 relative loss cost) is assumed to be the same as used for low-rise residential buildings. Table 12 shows the set of multipliers that should be used in conjunction with Table 7, as was done for single family homes. However, certain multipliers - such as garage type - are not applicable to commercial buildings.

Table 12: Multipliers for Commercial Low-rise Construction

Low Rise Multipiers	
Construction Multiplier	
Wood Frame / Unreinforced Masonry	1.00
Reinforced Masonry	0.90
Reinforced Concrete	0.55
Year-Built Multipliers	
Unknown	1.00
Pre 1995	1.05
1995-2006	0.90
Post 2006	0.80

Note: The reinforced concrete multiplier applies only for reinforced concrete structures with reinforced concrete roof slabs

New low-rise commercial buildings will be designed according to the International Building Code (IBC 2003). Depending upon their location, there will be different building code requirements. Table 12 provides the multipliers for low-rise commercial buildings built to new codes for different design wind speeds. Table 12 should be used in conjunction with Table 13 to estimate the loss relativities for low-rise commercial buildings.

Table 13: Relative Loss Costs for New Commercial Low-Rise (IBC 2003) Construction

NEW LOW-RISE COMMERCIAL CONSTRUCTION IRC/IBC 2003					ROOF GEOMETRY								
					GABLE END WITHOUT BRACING			GABLE END WITH BRACING			HIP		
					OPENING PROTECTION			OPENING PROTECTION			OPENING PROTECTION		
Wind Speed Zone	SECONDARY WATER PROTECTION	ROOF COVER & ATTACHMENT	ROOF DECK TYPE & ATTACHMENT	ROOF ANCHORAGE	NONE	Non-Engineered Shutter	Engineered Shutter	NONE	Non-Engineered Shutter	Engineered Shutter	NONE	Non-Engineered Shutter	Engineered Shutter
90 - 100 mph	No	Non-Wind Rated Roof Cover	PLYWOOD + Level B Attachment	Clips	0.95	0.80	0.66	0.93	0.76	0.61	0.93	0.75	0.60
	Yes	Non-Wind Rated Roof Cover	PLYWOOD + Level B Attachment	Clips	0.90	0.75	0.63	0.89	0.72	0.58	0.88	0.70	0.56
100 - 110 mph	No	Non-Wind Rated Roof Cover	PLYWOOD + Level B Attachment	Clips	0.95	0.80	0.66	0.93	0.76	0.61	0.93	0.75	0.60
	Yes	Non-Wind Rated Roof Cover	PLYWOOD + Level B Attachment	Clips	0.90	0.75	0.63	0.89	0.72	0.58	0.88	0.70	0.56
110 - 120 mph	No	110 MPH WIND RATED COVER	PLYWOOD + Level C Attachment	Hurricane Ties	0.73	0.58	0.46	0.73	0.56	0.42	0.73	0.55	0.41
	Yes	110 MPH WIND RATED COVER	PLYWOOD + Level C Attachment	Hurricane Ties	0.69	0.55	0.43	0.68	0.52	0.39	0.68	0.51	0.38
120 - 140 mph	No	110 MPH WIND RATED COVER	PLYWOOD + Level C Attachment	Hurricane Ties	0.73	0.58	0.46	0.73	0.56	0.42	0.73	0.55	0.41
	Yes	110 MPH WIND RATED COVER	PLYWOOD + Level C Attachment	Hurricane Ties	0.69	0.55	0.43	0.68	0.52	0.39	0.68	0.51	0.38

Notes

1) Relativities in this table are with respect to the same base building as in Table 12
2) Structure Year-built multiplier is not included in the relativities of this table and should be applied in calculation of final relativity

Commercial mid- and high-rise construction

Commercial mid- and high-rise buildings are generally of concrete and steel construction, with metal or concrete roof decks. Mid-rise buildings, however, could be constructed of masonry. Though it is unlikely, there can even be some mid-rise buildings constructed of wood. There is limited information about detailed building features for mid and high-rise commercial buildings. Typical mid- and high-rise buildings are assumed to have a glass percentage between 20% to 60%, annealed glass type, wall siding of EIFS type or equivalent, and with no secondary water protection. Metal roof deck with insulation is assumed to be the most common type of roof deck for mid and high-rise buildings. Table 14 provides the relative loss costs for mid- and high-rise commercial construction. Table 15 provides additional multipliers that should be used in conjunction with Table 14. The same procedure as described for low-rise commercial buildings can be used for estimation of overall mitigation credits and debits.

Since damage to mid- and high-rise structures is generally restricted to non-structural components such as wall siding and windows, detailed design calculations have not been done to compute design loads for building components of a commercial building. The effect of codes on non-structural components such as glass type and opening protection is important to consider for wind mitigation as they are most vulnerable to hurricane winds. For example, in a wind-borne debris region (design wind speed >120 mph in Mississippi), codes will require openings to be protected with impact-resistant glass or with shutters.

Table 14: Relative Loss Costs for Mid- and High-rise Commercial Construction

High-Rise and Mid-Rise Commercial Construction		Wall Siding	EIFS										
		Construction	Wood Frame		Reinforced Masonry					Reinforced Concrete			
		Roof Deck	Plywood		Plywood		Metal Deck/Insulation		Metal Deck / Concrete	Metal Deck/Insulation		Metal Deck / Concrete	Reinforced Concrete
		Secondary Water Protection	No	Yes	No	Yes	No	Yes	NA	No	Yes	NA	NA
Glass Type	Glass Percent	Opening Protection											
Annealed	More than 60%	None	1.16	1.10	1.29	1.21	1.16	1.09	0.93	1.45	1.37	1.16	0.87
		Non-Engineered	0.79	0.75	0.89	0.83	0.76	0.72	0.61	0.95	0.90	0.76	0.57
		Engineered	0.72	0.68	0.80	0.76	0.69	0.65	0.55	0.86	0.82	0.69	0.52
	20%-60%	None	1.00	0.94	1.11	1.05	1.00	0.94	0.80	1.25	1.18	1.00	0.75
		Non-Engineered	0.79	0.75	0.89	0.83	0.76	0.71	0.61	0.95	0.89	0.76	0.57
		Engineered	0.72	0.68	0.80	0.76	0.69	0.65	0.55	0.86	0.81	0.69	0.52
	5%-20%	None	0.86	0.81	0.96	0.90	0.84	0.78	0.67	1.05	0.98	0.84	0.63
		Non-Engineered	0.78	0.74	0.88	0.82	0.75	0.71	0.60	0.94	0.89	0.75	0.57
		Engineered	0.71	0.68	0.79	0.75	0.68	0.64	0.55	0.85	0.81	0.69	0.51
	Less than 5%	None	0.84	0.79	0.93	0.88	0.82	0.77	0.65	1.03	0.96	0.82	0.61
		Non-Engineered	0.78	0.74	0.88	0.82	0.75	0.71	0.60	0.94	0.89	0.75	0.57
		Engineered	0.71	0.68	0.79	0.75	0.68	0.64	0.55	0.85	0.81	0.68	0.51
Tempered	More than 60%	None	1.11	1.05	1.24	1.16	1.11	1.04	0.89	1.39	1.31	1.11	0.83
		Non-Engineered	0.79	0.75	0.88	0.83	0.76	0.71	0.61	0.95	0.89	0.76	0.57
		Engineered	0.71	0.68	0.80	0.75	0.69	0.65	0.55	0.86	0.81	0.69	0.52
	20%-60%	None	0.96	0.90	1.07	1.00	0.96	0.90	0.76	1.20	1.13	0.96	0.72
		Non-Engineered	0.79	0.75	0.88	0.83	0.76	0.71	0.60	0.95	0.89	0.76	0.57
		Engineered	0.71	0.68	0.80	0.75	0.68	0.65	0.55	0.86	0.81	0.69	0.52
	5%-20%	None	0.82	0.77	0.92	0.86	0.80	0.75	0.64	1.00	0.94	0.80	0.60
		Non-Engineered	0.78	0.74	0.87	0.82	0.75	0.71	0.60	0.94	0.88	0.75	0.56
		Engineered	0.71	0.67	0.79	0.75	0.68	0.64	0.55	0.85	0.80	0.68	0.51
	Less than 5%	None	0.80	0.75	0.89	0.83	0.78	0.73	0.62	0.98	0.92	0.78	0.58
		Non-Engineered	0.78	0.74	0.87	0.82	0.75	0.71	0.60	0.94	0.88	0.75	0.56
		Engineered	0.71	0.67	0.79	0.75	0.68	0.64	0.54	0.85	0.80	0.68	0.51
Laminated	More than 60%	None	1.09	1.03	1.22	1.14	1.09	1.03	0.87	1.37	1.28	1.09	0.82
		Non-Engineered	0.79	0.75	0.88	0.83	0.76	0.71	0.60	0.95	0.89	0.76	0.57
		Engineered	0.71	0.68	0.80	0.75	0.68	0.65	0.55	0.86	0.81	0.69	0.52
	20%-60%	None	0.94	0.89	1.05	0.98	0.94	0.88	0.75	1.18	1.10	0.94	0.70
		Non-Engineered	0.78	0.75	0.88	0.82	0.75	0.71	0.60	0.95	0.89	0.76	0.57
		Engineered	0.71	0.68	0.79	0.75	0.68	0.65	0.55	0.85	0.81	0.69	0.52
	5%-20%	None	0.81	0.76	0.90	0.84	0.78	0.73	0.62	0.98	0.92	0.78	0.58
		Non-Engineered	0.78	0.74	0.87	0.82	0.75	0.70	0.60	0.94	0.88	0.75	0.56
		Engineered	0.71	0.67	0.79	0.75	0.68	0.64	0.54	0.85	0.80	0.68	0.51
	Less than 5%	None	0.78	0.74	0.87	0.82	0.77	0.72	0.61	0.96	0.90	0.76	0.57
		Non-Engineered	0.78	0.74	0.87	0.82	0.75	0.70	0.60	0.94	0.88	0.75	0.56
		Engineered	0.71	0.67	0.79	0.74	0.68	0.64	0.54	0.85	0.80	0.68	0.51
Impact Resistant	More than 60%	Not Applicable	0.72	0.68	0.80	0.76	0.69	0.65	0.55	0.86	0.82	0.69	0.52
	20%-60%	Not Applicable	0.72	0.68	0.80	0.76	0.69	0.65	0.55	0.86	0.81	0.69	0.52
	5%-20%	Not Applicable	0.71	0.68	0.79	0.75	0.68	0.64	0.55	0.85	0.81	0.69	0.51
	Less than 5%	Not Applicable	0.71	0.68	0.79	0.75	0.68	0.64	0.55	0.85	0.81	0.68	0.51

High-Rise and Mid-Rise Commercial Construction		Wall Siding	Other Siding										
		Construction	Wood Frame		Reinforced Masonry					Reinforced Concrete			
		Roof Deck	Plywood		Plywood		Metal Deck/Insulation		Metal Deck / Concrete	Metal Deck/Insulation		Metal Deck / Concrete	Reinforced Concrete
		Secondary Water Protection	No	Yes	No	Yes	No	Yes	NA	No	Yes	NA	NA
Glass Type	Glass Percent	Opening Protection											
Annealed	More than 60%	None	1.00	0.94	1.12	1.05	1.00	0.94	0.80	1.00	0.94	0.80	0.60
		Non-Engineered	0.66	0.63	0.74	0.70	0.64	0.60	0.51	0.64	0.60	0.51	0.38
		Engineered	0.58	0.55	0.66	0.62	0.56	0.53	0.45	0.56	0.53	0.45	0.34
	20%-60%	None	0.86	0.81	0.96	0.90	0.86	0.81	0.69	0.86	0.81	0.69	0.51
		Non-Engineered	0.66	0.63	0.74	0.70	0.63	0.60	0.51	0.63	0.60	0.51	0.38
		Engineered	0.58	0.55	0.66	0.62	0.56	0.53	0.45	0.56	0.53	0.45	0.34
	5%-20%	None	0.73	0.70	0.82	0.77	0.71	0.67	0.57	0.71	0.67	0.57	0.43
		Non-Engineered	0.65	0.62	0.73	0.69	0.63	0.59	0.50	0.63	0.59	0.50	0.38
		Engineered	0.58	0.55	0.65	0.61	0.56	0.52	0.44	0.56	0.52	0.44	0.33
	Less than 5%	None	0.71	0.67	0.79	0.75	0.69	0.66	0.56	0.69	0.66	0.56	0.42
		Non-Engineered	0.65	0.62	0.73	0.69	0.63	0.59	0.50	0.63	0.59	0.50	0.38
		Engineered	0.57	0.54	0.65	0.61	0.55	0.52	0.44	0.55	0.52	0.44	0.33
Tempered	More than 60%	None	0.95	0.90	1.06	1.00	0.95	0.89	0.76	0.95	0.89	0.76	0.57
		Non-Engineered	0.66	0.62	0.74	0.70	0.63	0.60	0.51	0.63	0.60	0.51	0.38
		Engineered	0.58	0.55	0.66	0.62	0.56	0.53	0.45	0.56	0.53	0.45	0.34
	20%-60%	None	0.81	0.77	0.91	0.85	0.81	0.77	0.65	0.81	0.77	0.65	0.49
		Non-Engineered	0.65	0.62	0.74	0.69	0.63	0.59	0.51	0.63	0.59	0.51	0.38
		Engineered	0.58	0.55	0.65	0.62	0.56	0.53	0.45	0.56	0.53	0.45	0.33
	5%-20%	None	0.69	0.66	0.77	0.73	0.67	0.63	0.54	0.67	0.63	0.54	0.40
		Non-Engineered	0.65	0.62	0.73	0.69	0.62	0.59	0.50	0.62	0.59	0.50	0.38
		Engineered	0.57	0.54	0.65	0.61	0.55	0.52	0.44	0.55	0.52	0.44	0.33
	Less than 5%	None	0.67	0.64	0.75	0.71	0.66	0.62	0.53	0.66	0.62	0.53	0.40
		Non-Engineered	0.65	0.61	0.73	0.69	0.62	0.59	0.50	0.62	0.59	0.50	0.37
		Engineered	0.57	0.54	0.65	0.61	0.55	0.52	0.44	0.55	0.52	0.44	0.33
Laminated	More than 60%	None	0.92	0.88	1.04	0.98	0.93	0.88	0.74	0.93	0.88	0.74	0.56
		Non-Engineered	0.66	0.62	0.74	0.69	0.63	0.60	0.51	0.63	0.60	0.51	0.38
		Engineered	0.58	0.55	0.65	0.62	0.56	0.53	0.45	0.56	0.53	0.45	0.34
	20%-60%	None	0.79	0.76	0.89	0.84	0.79	0.75	0.64	0.79	0.75	0.64	0.48
		Non-Engineered	0.65	0.62	0.73	0.69	0.63	0.59	0.50	0.63	0.59	0.50	0.38
		Engineered	0.58	0.55	0.65	0.61	0.56	0.52	0.45	0.56	0.52	0.45	0.33
	5%-20%	None	0.68	0.64	0.76	0.71	0.66	0.62	0.53	0.66	0.62	0.53	0.39
		Non-Engineered	0.65	0.61	0.73	0.69	0.62	0.59	0.50	0.62	0.59	0.50	0.37
		Engineered	0.57	0.54	0.64	0.61	0.55	0.52	0.44	0.55	0.52	0.44	0.33
	Less than 5%	None	0.65	0.62	0.73	0.69	0.64	0.61	0.51	0.64	0.61	0.51	0.39
		Non-Engineered	0.65	0.61	0.73	0.69	0.62	0.59	0.50	0.62	0.59	0.50	0.37
		Engineered	0.57	0.54	0.64	0.61	0.55	0.52	0.44	0.55	0.52	0.44	0.33
Impact Resistant	More than 60%	Not Applicable	0.58	0.55	0.66	0.62	0.56	0.53	0.45	0.56	0.53	0.45	0.34
	20%-60%	Not Applicable	0.58	0.55	0.66	0.62	0.56	0.53	0.45	0.56	0.53	0.45	0.34
	5%-20%	Not Applicable	0.58	0.55	0.65	0.61	0.56	0.52	0.44	0.56	0.52	0.44	0.33
	Less than 5%	Not Applicable	0.57	0.54	0.65	0.61	0.55	0.52	0.44	0.55	0.52	0.44	0.33

Table 15: Multipliers and Modifiers for Commercial High-rise Commercial Construction

Mid-Rise / High-Rise Multipiers	
Construction Multiplier	
Wood Frame / Unreinforced Masonry	1.00
Reinforced Masonry	0.85
Concrete	0.40
Year-Built Multipliers	
Unknown	1.00
Pre 1995	1.05
1995-2006	0.90
Post 2006	0.80

Consideration of Feature Costs

Cost Data Sources

In order to estimate the cost of retrofitting individual residential mitigation features onto existing structures, it is necessary to create cost "assemblies", or groups of cost components that reflect the work required to install each feature. For example, an assembly describing the replacement of an existing roof cover with wind rated shingles will include the labor to remove the old roof cover, the hauling and disposal fees of the debris, the material required for the new roof (roofing felt, shingles, nails, drip edge, etc.) and the labor required to install those materials. In this study, the basis for these cost building blocks is data provided by Xactware Solutions, Inc.

Xactware has been researching and providing construction cost information as part of its software solutions for the insurance-repair (claims) market for over 20 years. The information is gathered continually and the databases are updated each month. Databases are populated and updated in two ways:

- Top-down approach - where information is provided from estimates/bids written for the purpose of settling claims;
- Bottom-up approach - where individual labor, material and equipment component costs are surveyed from construction suppliers and contractors.

Cost databases are available for over 460 economic areas of North America; this study used a database specific to coastal Mississippi, so it was not necessary to apply location adjustments to the derived costs.

The Xactware data has been supplemented with some specific and detailed material costs gathered from suppliers using Internet-based resources.

Residential Feature Cost Calculations

This analysis calculated a typical cost to retrofit existing structures with each mitigation feature. To proceed, assumptions were made regarding building characteristics unrelated to hurricane wind loss mitigation. These characteristics, such as structure size, number of stories, roof slope, roof overhang, number and size of windows, and exterior door type, are required in order to perform the construction cost estimation. The assumptions are based on AIR's proprietary data and modeling supplemented by expert opinion.

The building methods used to consider installation and retrofitting of the mitigation features are based on construction best practices supplemented by information provided by sources such as the Institute for Business and Home Safety, the Florida Division of Emergency Management and publications such as Coastal Contractor Online. Using these sources, along with the cost data mentioned earlier, it is possible to create individual cost "building blocks" that when integrated over successive or multiple features, allow the development of a table of combined retrofit cost estimates. The result is shown in Table 16. All costs are expressed in constant present-day dollars and do not consider financing costs or demand surge associated with sudden increases in costs after hurricanes.

Table 16: Residential Retrofit Cost Estimate Matrix

OCCUPANCY: SINGLE FAMILY HOME					ROOF GEOMETRY								
					GABLE END WITHOUT BRACING			GABLE END WITH BRACING			HIP		
					WINDOW PROTECTION			WINDOW PROTECTION			WINDOW PROTECTION		
CONSTRUCTION TYPE	SECONDARY WATER PROTECTION	ROOF COVER & ATTACHMENT	ROOF DECK TYPE & ATTACHMENT	ROOF ANCHORAGE	NONE	Non-Engineered Shutter	Engineered Shutter	NONE	Non-Engineered Shutter	Engineered Shutter	NONE	Non-Engineered Shutter	Engineered Shutter
WOOD FRAME	NO	NON-WIND RATED COVER	PLYWOOD + (6d @ 6" / 12")	NAILS / SCREWS	-	375	3,500	300	675	3,800	-	375	3,500
				CLIPS	1,650	2,025	5,150	1,950	2,325	5,450	2,000	2,375	5,500
				HURRICANE TIES	2,000	2,375	5,500	2,300	2,675	5,800	2,500	2,875	6,000
			PLYWOOD + (8d @ 6" / 12")	NAILS / SCREWS	5,100	5,475	8,600	5,400	5,775	8,900	5,100	5,475	8,600
				CLIPS	6,100	6,475	9,600	6,400	6,775	9,900	6,450	6,825	9,950
				HURRICANE TIES	6,450	6,825	9,950	6,750	7,125	10,250	6,950	7,325	10,450
			PLYWOOD + (8d @ 6" / 6")	NAILS / SCREWS	5,200	5,575	8,700	5,500	5,875	9,000	5,200	5,575	8,700
				CLIPS	6,200	6,575	9,700	6,500	6,875	10,000	6,550	6,925	10,050
				HURRICANE TIES	6,550	6,925	10,050	6,850	7,225	10,350	7,050	7,425	10,550
		110 MPH WIND RATED COVER	PLYWOOD + (6d @ 6" / 12")	NAILS / SCREWS	5,700	6,075	9,200	6,000	6,375	9,500	5,700	6,075	9,200
				CLIPS	6,700	7,075	10,200	7,000	7,375	10,500	7,050	7,425	10,550
				HURRICANE TIES	7,050	7,425	10,550	7,350	7,725	10,850	7,550	7,925	11,050
			PLYWOOD + (8d @ 6" / 12")	NAILS / SCREWS	6,200	6,575	9,700	6,500	6,875	10,000	6,200	6,575	9,700
				CLIPS	7,200	7,575	10,700	7,500	7,875	11,000	7,550	7,925	11,050
				HURRICANE TIES	7,550	7,925	11,050	7,850	8,225	11,350	8,050	8,425	11,550
			PLYWOOD + (8d @ 6" / 6")	NAILS / SCREWS	6,300	6,675	9,800	6,600	6,975	10,100	6,300	6,675	9,800
				CLIPS	7,300	7,675	10,800	7,600	7,975	11,100	7,650	8,025	11,150
				HURRICANE TIES	7,650	8,025	11,150	7,950	8,325	11,450	8,150	8,525	11,650
	YES	NON-WIND RATED COVER	PLYWOOD + (6d @ 6" / 12")	NAILS / SCREWS	5,600	5,975	9,100	5,900	6,275	9,400	5,600	5,975	9,100
				CLIPS	6,600	6,975	10,100	6,900	7,275	10,400	6,950	7,325	10,450
				HURRICANE TIES	6,950	7,325	10,450	7,250	7,625	10,750	7,450	7,825	10,950
			PLYWOOD + (8d @ 6" / 12")	NAILS / SCREWS	6,100	6,475	9,600	6,400	6,775	9,900	6,100	6,475	9,600
				CLIPS	7,100	7,475	10,600	7,400	7,775	10,900	7,450	7,825	10,950
				HURRICANE TIES	7,450	7,825	10,950	7,750	8,125	11,250	7,950	8,325	11,450
			PLYWOOD + (8d @ 6" / 6")	NAILS / SCREWS	6,200	6,575	9,700	6,500	6,875	10,000	6,200	6,575	9,700
				CLIPS	7,200	7,575	10,700	7,500	7,875	11,000	7,550	7,925	11,050
				HURRICANE TIES	7,550	7,925	11,050	7,850	8,225	11,350	8,050	8,425	11,550
		110 MPH WIND RATED COVER	PLYWOOD + (6d @ 6" / 12")	NAILS / SCREWS	6,700	7,075	10,200	7,000	7,375	10,500	6,700	7,075	10,200
				CLIPS	7,700	8,075	11,200	8,000	8,375	11,500	8,050	8,425	11,550
				HURRICANE TIES	8,050	8,425	11,550	8,350	8,725	11,850	8,550	8,925	12,050
			PLYWOOD + (8d @ 6" / 12")	NAILS / SCREWS	7,200	7,575	10,700	7,500	7,875	11,000	7,200	7,575	10,700
				CLIPS	8,200	8,575	11,700	8,500	8,875	12,000	8,550	8,925	12,050
				HURRICANE TIES	8,550	8,925	12,050	8,850	9,225	12,350	9,050	9,425	12,550
			PLYWOOD + (8d @ 6" / 6")	NAILS / SCREWS	7,300	7,675	10,800	7,600	7,975	11,100	7,300	7,675	10,800
				CLIPS	8,300	8,675	11,800	8,600	8,975	12,100	8,650	9,025	12,150
				HURRICANE TIES	8,650	9,025	12,150	8,950	9,325	12,450	9,150	9,525	12,650

In order to fully understand the chart we must recognize that in many cases, work necessary to address one mitigation feature will overlap the work required to install a separate feature. In some cases there is full overlap. For example, improvement to the nailing pattern of a roof deck requires the removal of the roof cover, which is also required when upgrading the roof cover to wind rated shingles. In other cases there is partial overlap; an example is the addition of hurricane ties as roof anchors, which require removal of a portion of the roof. From a construction point of view these separate tasks are more efficient when performed in combination, and from a practical point of view it may not make sense to do one without the other. An example extracted from Table 16 reflects these efficiencies and is shown below in Table 17.

Table 17: Examples of Retrofit of Multiple Features - Base Structure: 1,500 Sq Ft, Home, Roof Geometry of Hip

Mitigation Features	Cost of Mitigation
Base Structure	-
Roof Deck Attachment: 8d@ 6" / 12"	5,100
Wind Rated Shingles	5,700
Roof Deck Attachment: 8d@ 6" / 12" Wind Rated Shingles	6,200

Mitigation Features	Cost of Mitigation
Base Structure	-
Hurricane Ties at Roof Rafter / Wall Connection	2,000
Wind Rated Shingles	5,700
Hurricane Ties at Roof Rafter / Wall Connection and Wind Rated Shingles	7,050

If there were no overlap in the work performed, to mitigate from the base building to an improved nailing pattern and wind rated shingles would cost $10,800 ($5,100 + $5,700) and similarly to mitigate from the base building to hurricane ties and wind rated shingles would cost $9,000. The efficiency is worth approximately 40% in the first case where there is nearly complete overlap, and about 15% in the second where there is partial overlap.

Because of this overlap it is also necessary to present all costs relative to a base building. For this analysis the following base building was defined: first, a wood framed, hip roof structure with average (not high wind rated) asphalt shingles, a plywood roof deck attached with 6d nails at 6"/12" spacing without secondary water protection, no hurricane clips or ties at the roof rafter / wall connection and no existing window protection.

Since costs are relative to the base building they are only applicable in that manner. Using the above extraction as an example, it will cost on average $5,700 to replace the roof cover of the base building with wind resistive shingles and $6,200 to retrofit the base building with both an improved roof deck nailing pattern and wind rated shingles. However because of the overlap, the chart cannot be used to determine the cost of retrofitting a structure that already has wind rated shingles with an improved roof deck nailing pattern to be $500 ($6,200 – $5,700). In fact, the work would require removal and installation of a new roof cover, which is not reflected in the $600 difference between the cells.

Limitations on Feature Cost Analysis

Construction cost estimation, even under stable economic conditions, is at best a fuzzy science and no single approach can adequately capture all of the variation possible among the building stock of coastal Mississippi. In all cases the uniqueness of an individual structure can result in differences in construction prices. Specifically, complexity in building shape, complicated roof shapes with multiple ridges and valleys, varying number of stories, roof overhangs of different lengths and differences in wood framing methodologies can all contribute to creating a range of reasonable cost estimates. Decisions by a building owner, such as the type of window shutter or the aesthetic characteristics of a roof shingle, can also cause variation.

It is also important to note that these costs reflect a snapshot in time; construction costs are a moving target and are constantly in flux. Supply and demand pressures, individual material and labor cost changes, and even outside influences such as the price of oil can contribute to movement in construction costs.

The costs presented in Table 17 are applicable to single family residential structures, but can also be relevant to light commercial buildings that have similar structural characteristics. However as the scale of the building increases (such as for larger mid- and high-rise commercial structures), so too does the magnitude of the factors mentioned above. Because of this uncertainty and the associated large deviation in mitigation feature costs for large scale buildings, an average cost can become less meaningful. For this Study we have focused on the opportunities of highest priority as expressed by MID and in the Scope, namely the encouragement of residential wind loss mitigation.

Author's Note: Additional analysis on commercial retrofit opportunities may be provided in a later release of the Study or as an Addendum if desired by MID.

Synthesizing Costs and Benefits to Determine Best Mitigation Actions

Conversion of Relativities to Estimated Dollar Loss Benefits Over Time

The major challenge in marrying an analysis of insurance benefits with an analysis of retrofit costs for similar combinations of mitigation features is the fact that insurance benefits are calculated based on relative loss costs, and insurance rates are applied to insured values to obtain premiums. Assuming insured and replacement values are aligned through proper underwriting and property valuation, benefits thus accrue to a property owner in the form of lower insurance premiums, but <u>in proportion to the replacement value</u> of the property. On the other hand, costs are fundamentally estimated in dollar amounts.

However, it is possible to make a conversion by aligning the basic replacement value underlying the cost estimates (in this case, $150,000) with the value underlying the average annual losses used to calculate the loss costs and relative loss costs (in this case, $100,000), then converting both benefits and costs to annual dollars.

There are hundreds of potential retrofit combinations which can be analyzed using the tables above, depending on the initial state of the property and the desired combination of features after mitigation actions are taken. Rather than an overwhelming analysis of possible combinations, it makes sense to focus on the costs and benefits of specified “mitigation packages” representing typical retrofit opportunities given the current building stock and construction methods. Our choices in this regard are common and practical, and / or are recognized by the MWUA.

The approach is as follows:

- Identify the packages of improvements under consideration. The most likely candidates for mitigation will be homeowners constructing new homes or renovation of existing homes due to deterioration or a loss event. In our examples, we have assumed that the existing home already needs to be repaired and that the owner is deciding on whether to replace or repair the damaged structure with like kind and quality or to upgrade to make it less damageable.
- Determine both the total policy premium and the hurricane portion of premium using the rating algorithm of the individual company. We have used sample simplified rating plans similar to those discussed in the insurance benefits section. Calculate the reduction in hurricane average annual losses by applying the credit (relative loss cost subtracted from 1.00) associated with that property in the insurance benefits tables.
- Calculate the net cost of retrofit from an “unmitigated” condition for a building with damage using the feature cost estimates in the tables less the cost to repair or replace with like kind and quality of existing construction.
- Adjust the cost of retrofit borne by the consumer for any available grant money, whether paid up-front or as reimbursement after the work has been completed.
- Compare the net cost to the consumer with the corresponding insurance benefit and calculate a “payback period” expressed in the number of years necessary to earn back the net costs of mitigation through lower annual insurance premiums.

This approach is expressed in constant dollars and does not consider changes in insurance market conditions, reinsurance costs, or general economic and construction cost inflation.

Cost-Benefit Analysis of Actionable Mitigation “Packages” of Retrofits

For this analysis we have selected two possible mitigation packages, organized by the practicality of performing one or more upgrades meant to make the structure stronger and safer during a typical retrofit construction job. These packages have been selected in part because they are aligned well with mitigation packages offered by the MWUA, with certain limitations

Roof Mitigation Package #1 – Starting with a structure that has a hip roof, replacing the roof cover with wind-rated shingles, and improving the roof deck attachment to Level B (8d nails @ 6”/12” spacing).

Roof Mitigation and Envelope Protection Package #2 - Starting with a structure that has a hip roof, replacing the roof cover with wind-rated shingles, improving the roof deck attachment with additional and better fasteners (8d nails @ 6”/6” spacing), anchoring the roof to the walls with hurricane ties, and installing Secondary Water Protection, plus installing engineered shutters on all openings. The work performed is assumed to replicate the MWUA's A - Roof System, B – Opening Protection, and C – Roof Surface credit criteria, with the exception of the soffit protection limitation described above and the fact that it does not include the mitigation action of reinforcing the garage door. This is very close to the maximum amount of wind mitigation that can be performed to a structure.

Both of the following worked examples for the mitigation improvement packages apply for a 1,500-square-foot home valued at $150,000 to replace located in the same neighborhood as the home for which previous examples were determined.

The base structure we are starting with is assumed to possess the following structural characteristics:

- Construction type of unreinforced masonry;
- Year built of 1990;
- Roof geometry of hip;
- Roof cover of non wind-rated shingles;
- Roof deck attachment of Level A (plywood with 6d nails @ 6"/12" spacing);
- Roof anchorage of nails/screws;
- No secondary water protection;
- No window protection;
- Two-car garage with standard (un-braced) door;
- No pool enclosure.

As outlined in the insurance benefits analysis section, the original total premium for this home was $3,476. This does not account for any mitigation credits, nor does it account for several specific attributes of the structure – notably the age, roof geometry, roof system details, presence or absence of envelope protection, and presence or absence of a pool enclosure. Insurers often do not know which homes may already have some mitigation features already in place. They generally must assume a mix exists between unmitigated and partially mitigated homes, and existing premiums and actuarial indications reflect that mix.

For the payback period calculations, we are assuming that for this risk there is already a need to repair the structure in some way, perhaps because of wind damage to the roof or due to deterioration over time. The choice for the homeowner is whether to perform repairs with like kind and quality, restoring the home to original built condition, or to upgrade it to include features that mitigate against hurricane winds. We consider the "gross" cost of mitigation to be the overall cost for the work performed to on the structure, and the "net" cost of mitigation to be the incremental additional cost above that which would be needed to return the structure to its pre-damaged or pre-deteriorated condition. For this home, it was determined that it would cost $4,600 to replace its damaged or worn-out roof with the same kind and quality of materials as originally used in its construction. This is the base cost used to determine the net cost of mitigating for the examples to follow.

It is also possible that grant money could be made available to homeowners to install mitigation features. This would further reduce the cost to the homeowners, and further reduce the payback period. In the examples that follow, we have assumed a 50% grant to the net cost of mitigation to be paid upon completion and verification of the work.

The assumptions that grant money could be made available, and that it would be applied to the net costs of mitigation, have a significant impact on the payback period calculations. There are complications with possibly applying grant money to the net costs of mitigation, and these must be considered in the Program's implementation. This is a simplifying assumption made for the purposes of these examples, but the authors of this report are not necessarily endorsing this method of implementation.

The approach for determining the payback period for the owner to recoup this incremental cost is summarized in the following algorithm:

Feature Cost Estimate (from Table 16)
Less cost to repair or replace with like kind and quality (independently determined)
Less grant contribution (assumed)
÷ Reduction in Insurance Costs (from comparison of annual policy premiums before and after mitigation

= Payback Period

The ratio of the feature cost to the annual savings is the "payback period" or period of time over which the homeowner would accumulate insurance premium reductions in sufficient amounts to offset the initial cost of the installation (not adjusted for the time value of money).

Example #1 – Homeowner has either existing insured damage or deterioration due to aging or condition that requires some action and chooses Roof Mitigation Package #1

The table below illustrates a computation of payback periods for roof mitigation package #1:

Table 18: Payback Periods for Roof Mitigation Package #1

Item	Source	Description	Amount
[1]	Assumed	Current Premium	3,476
[2]	Calculated Using Insurance Benefits Methodology	Fair Premium With Mitigation Credit Applied to Entire Hurricane Premium	3,049
[3]	Report	Total Mitigation Feature Cost from Table 14	6,200
[4]	Report	Incremental Cost of Repairing with Mitigation	1,600
[5]	Assumed	Grant Contribution	50%
[6]	[4]x(1-[5])	Incremental Cost of Repairing with Mitigation after Grant Contribution	800
[7]	[3]/([1]-[2])	Payback Period Based on Fair Premium before Considering Necessary Repair Costs	14.5
[8]	[4]/([1]-[2])	Payback Period Based on Current Premium after Considering Necessary Repair Costs	3.7
[9]	[6]/([1]-[2])	Payback Period Based on Current Premium after Considering Necessary Repair Costs and Grant Contribution	1.9

The premium in this example is reduced from $3,476 to $3,049. This reflects the savings due to the actions explicitly taken by the homeowner, as well as additional information about the structure such as the age (1990), roof shape (hip), and presence of an unreinforced garage door. These structural features were previously not known to the insurer and taken into account in the premium calculation.

The gross cost of mitigation is $6,200 – this is the cost of replacing the roof with Level B roof deck anchorage and wind rated roof covering. Without accounting for the cost of repairing the roof to its original state (like kind and quality) or considering any grant contributions, the payback period would be approximately 15 years.

However, when we add in consideration of the costs necessary to repair the roof with like kind and quality materials, the net cost of mitigation is reduced to $1,600, and the payback period is reduced to approximately 4 years.

If we then account for a grant contribution equal to 50% of the net cost of mitigation, the payback period is reduced to approximately 2 years.

Example #2 – Homeowner has either existing insured damage or deterioration due to aging or condition that requires some action and chooses Roof Mitigation and Envelope Protection Package #2

The table below illustrates a computation of payback periods for roof mitigation package #2:

Table 19: Payback Periods for Roof Mitigation Package #2

Item	Source	Description	Amount
[1]	Assumed	Current Premium	3,476
[2]	Calculated Using Insurance Benefits Methodology	Fair Premium With Mitigation Credit Applied to Entire Hurricane Premium	1,585
[3]	Report	Total Mitigation Feature Cost from Table 14	12,650
[4]	Report	Incremental Cost of Repairing with Mitigation	8,050
[5]	Assumed	Grant Contribution	50%
[6]	[4]x(1-[5])	Incremental Cost of Repairing with Mitigation after Grant Contribution	4,025
[7]	[3]/([1]-[2])	Payback Period Based on Fair Premium before Considering Necessary Repair Costs	6.7
[8]	[4]/([1]-[2])	Payback Period Based on Current Premium after Considering Necessary Repair Costs	4.3
[9]	[6]/([1]-[2])	Payback Period Based on Current Premium after Considering Necessary Repair Costs and Grant Contribution	2.1

The premium in this example is reduced from $3,476 to $1,585, which is a 54% reduction in the total premium. This results from a 62% reduction in the hurricane AAL. This is close to the maximum amount of credit that one can achieve to mitigating an existing structure.

The gross cost of mitigation is $12,650 – this is the cost of replacing the roof with Level C roof deck anchorage, secondary water protection, wind rated roof covering, and hurricane ties, and installing engineered shutters. Without accounting for the cost of repairing the roof to its original state (like kind and quality) or considering any grant contributions, the payback period would be approximately 7 years.

However, when we add in consideration of the costs necessary to repair the roof with like kind and quality materials, the net cost of mitigation is reduced to $8,050, and the payback period is reduced to approximately 4 years.

If we then account for a grant contribution equal to 50% of the net cost of mitigation, the payback period is reduced to approximately 2 years.

Hurricane loss mitigation has many other benefits to life and property, both direct and indirect, as discussed below. Benefits could include potential increases in market value, favorable underwriting with more insurance choices and of course longer life of materials and resulting lower amortized maintenance costs.

It is beyond the scope of this Study for the authors to speculate on how a grant program should be defined for the state of Mississippi. However, these two mitigation payback examples suggest that the presence of mitigation grant money to help defray some of the cost to homeowners could provide significant encouragement for their taking significant action to have their homes strengthened against damage from future hurricane force winds and wind-borne debris.

Scoping the Program: Implementation of Study Results

Actuarial and Insurance Product Considerations

Though there are common elements among underwriting guidelines and rating plans, particularly in residential lines of business, each insurer ultimately must file with MID and implement a company-specific risk acceptance and rating algorithm. Because a key element of the Program is the encouragement of an enhanced rating plan for insurers targeting mitigation features, Mississippi faces a transition process during which new rating elements and instructions may be "bolted on" to existing plans. One might think insurers and their actuaries can start "from scratch" and rebuild loss costs, base rates, and class rating factors, but there are several impediments to this ideal:

1. Many elements are required by statutes and regulations which have evolved as a patchwork over time, creating an imperfect and often duplicative approach to rating. Nonetheless, insurers cannot ignore or defy existing statutory and regulatory requirements when meeting new goals or mandates, and must take care to comply even when existing and new elements may be in conflict, actuarially speaking.

2. Current rating and quoting systems typically embody a tremendous investment in complex information technology, interconnected with nearly all other systems in the organization. It is typically a monumental internal task to radically change the way policies are underwritten, rated, processed, and issued.

3. Market disruptions are common when changes in the rating plan inevitably affect some consumers much differently than others. Adjusting base rates to achieve a new overall revenue level is relatively simple. Installing a new classification plan based on rating elements which are not currently captured by the quote/sale system results in effects on individual policy premiums which are often significant, volatile, and unpredictable (because the current book of business cannot easily be re-rated on proposed rates which depend on nonexistent data). As a result, insurers are reluctant to implement anything which might generate consumer complaints, cancellations, or competitive upheaval in target markets.

AIR, as a modeling firm, certainly does not have all the answers to these problems. However, we can offer consideration of some specific issues and options as the MID determines how to use any results from this Study to encourage greater granularity in the underwriting and rating of individual properties based on hurricane wind loss mitigation features.

Alignment with Existing Book of Business

First, the effective or implied "base structure" underlying each insurer's current rates should receive individualized attention. It is necessary for us to make broad assumptions about the distribution of the building stock in order to calculate relative loss costs. Because insurers are highly competitive and often niche-focused in underwriting, any one insurer's book may not exhibit a similar building stock distribution. Insurers should have the opportunity to research, define, and justify current rate level adequacy and the implied base structure underlying current rates, then adjust base rates and relative loss costs accordingly so that the proper mitigation credits and debits are applied in the rating algorithm after the mitigation plan has been incorporated. The result should promote the twin goals of actuarially sound rates[7]:

- **Efficiency** – collection of sufficient overall revenue to annually fund the expected value of all costs associated with accepting or transferring the risk of the anticipated book of business;
- **Equity** – differentiation of premiums among properties in accordance with best estimates of the expected value of all costs associated with each individual risk.

We have attempted to transparently define our choice of base structures in the various insurance benefits tables in order to promote this type of analysis by insurers and MID.

Second, it is important to consider the lines of business and portion of premium to which the mitigation rating procedure should be applied. Our analysis is engineering-based as well as based on hurricane wind simulations only. Therefore, it is focused on only the main structures insured, and only on the hurricane wind and windborne debris perils. In particular, we have not addressed storm surge, tornado-hail ("other wind"), or obviously any unrelated perils like fire, lightning, and theft.

However, the unfortunate fact is that insurers have to consider numerous practical problems with the applicability of a mitigation rating plan, such as:

- Many insurers rate residential policies on the basis of an "indivisible" or single premium charged for all covered perils, making the separation of the hurricane portion of premium difficult. We have provided **hypothetical**, but reasonable, rating examples which assume an ability to actuarially justify and separate the hurricane portion of premium.
- Structure, contents, and time element coverages are rated separately. We have provided mitigation relativity tables based upon analysis of structures only. A key decision for insurers is how premiums for other property coverages (appurtenant structures, contents, time element) should be modified for mitigation to the structure. In the hypothetical rating examples we made the simplified assumption that the same mitigation benefit as determined for the structure would extend to the other coverages.
- Each line of business is rated separately, and it is not clear how to apply mitigation analysis to policies where the main structure is not covered (such as renters and condominium unit-owners policies).

Insurers should be strongly encouraged to perform the actuarial exercise, possibly involving catastrophe modeling, necessary to report and rate hurricane premium separately for purposes of implementing mitigation incentives. Agreement among insurers and MID should be reached as to

[7] The definition of "actuarially sound" rates is often vague as used in public statements, particularly by non-actuaries, but can be found in the Casualty Actuarial Society's Statement of Principles on Property-Casualty Insurance Ratemaking. The "efficiency" and "equity" definitions used here paraphrase those principles.

how to apply mitigation rating plans to renters and unit-owners policies, as well as to structure, appurtenant structures, contents, and time element coverages.

Third, the existing rating algorithm should be examined for duplicative credits and debits which can be partially (by tempering of debit/credit values) or totally superseded by the individual risk mitigation rating plan. Insurers commonly rate for several inputs discussed in this Study:

Age of Home - credits and debits linked solely to year built are often used in current plans and typically apply multiplicatively and independently of other rating factors. Further, they often apply to the entire premium, not just the portion dedicated to hurricane. The overlap between the effect of age of home adjustments to the hurricane portion of premium and the mitigation plan should be analyzed.

Building Code Effectiveness Grading – the ISO BCEGS system judges the effectiveness and enforcement of local building codes in thousands of U.S. jurisdictions, but AIR also implicitly considers code improvements and their effectiveness in our separation of year built bands and particularly our separation post-IRC 2003 construction. It is not immediately clear how much the BCEGS system should be tempered or superseded, as applied to hurricane premium, as a full mitigation rating plan is implemented.

Construction Type – Insurers typically rate for wall construction type, but in much less refined manner than AIR codes and feature definitions allow for. Frequently, construction type rating is limited to frame or masonry categories embedded within a “construction and protection factor” table designed for fire perils but applied to the entire premium including that for hurricane. Further, a separate, multiplicative, independent “superior construction credit” may be offered for reinforced masonry or non-combustible risks. It is important to note that our tables have been designed to apply to both frame and masonry wall construction, in order to minimize the overlap between existing construction type rating and the plan presented here. However, the superior construction credit is implicitly considered in our Reinforced Masonry category of mitigation features operating as a system, and so any overlap due to the use of this credit could be considered for tempering or removal from the hurricane portion of the premium.

Territory – Insurers nearly always rate by geographic territory, though companies use a variety of definitions. Our Study is designed to interfere with current territory rating as little as possible, in that the base risks for existing and new construction do not vary over the Study region. The credits for mitigated risks in high wind speed zones reflect the assumption that the base rate for those risks will already depend on their catastrophe exposure as measured by loss costs.

Deductible – Insurers typically offer credits for higher deductibles. Our Study assumes a common 2% base deductible. Insurers using other dollar amount or percentage deductibles as their base for rating may need to adjust their mitigation factors to account for the differences.

Existing Mitigation Features – Insurers in some states are already required to reflect rating factors for certain features, most commonly opening protection. Notwithstanding any requirements in Mississippi, some insurers may have voluntarily implemented certain mitigation discounts in the state. Any overlap between the effect of existing mitigation discounts and a more robust plan based in part on this Study should be considered.

Risk Transfer – The cost of hurricane wind risk transfer, predominantly through reinsurance, is typically represented actuarially as a fixed expense for the period in which rates will be in effect. There should be no direct overlap between the existing rating algorithm and the mitigation algorithm designed in this Study, but the use of a mitigation plan raises the question of whether reduced average annual hurricane wind losses should result in lower reinsurance premiums and therefore lower fixed expenses in the rate base. Reinsurer charges (ceded premiums) can be visualized as the ceded portion of the AAL plus a "risk load." The risk load is based on the cost of holding the massive amounts of claims-paying capital required at almost a moment's notice after a hurricane. Because storms can strike in any year, insurers do not have the luxury of funding hurricanes through premium rates by slowly building up capital over time via a small cost of capital or profit load in rates. Instead, the lion's share of that capital is "rented" from reinsurers, who charge a risk load based on the probability they will lose it in a storm.

The low-frequency, high-impact nature of hurricanes means the potential loss (sometimes called "probable maximum loss" or PML) is many times the average loss for most property lines. Consequently, the risk load within a reinsurance premium is also typically a multiple of the expected loss. When expected losses decline, reinsurance costs should also decline, but the degree of decline is highly uncertain because the risk load drives the reinsurance cost and it is based on the severe loss potential, not the average. The question for our purposes becomes whether the mitigation credit/debit for a policy should be applied to the entire hurricane premium, only the expected loss portion of the hurricane premium, or to some weighted compromise value. Insurers must carefully study and justify their assumptions regarding reinsurance cost dynamics in the face of a comprehensive rating plan for mitigation.

An extension of this Study could give greater scrutiny to the full modeled hurricane loss distributions underlying the results and, under certain assumptions about reinsurance pricing techniques, further investigate the issue of the interaction between mitigation and costs of capital.

Finally, though it is more difficult to quantify, the effect of implementing consideration of individual risk mitigation on underwriting guidelines should not be overlooked. Risks exhibiting certain attributes may have been unprofitable under a less refined rating plan, and therefore discouraged for acceptance by underwriting guidelines, but more acceptable under a more sophisticated plan which accounts for mitigation features. Actuarial theory indicates that the more refined the rating plan – as long as the rating factor values are sufficiently credible – the more properties may be written within an existing capital or profitability constraint. This greater efficiency in the use of insurance capital ultimately squares with desirable public policy – availability and affordability of coastal property insurance.

Transition Plans and Swing Limits

It is virtually impossible to implement a complex new set of rating tables based on a mitigation Study and make broad generalizations about the premium impact on individual policies and its distribution across the overall book of business. Several factors discussed above favor the promotion of premium stability notwithstanding the steady move to a more refined and accurate rating plan for individual risks. One effective way to isolate the stability problem from the problem of improving a rating plan in an actuarially sound manner is to provide for a transition plan in premiums, sometimes known as “swing limits” or “circuit breakers,” which operate by limiting the annual premium change – adjusted for changes in replacement value amounts and coverage changes – for any one policy. The swing limit can be determined by the insurer (often with the consultation of the regulator) reflecting competitive, consumer protection, and revenue (actuarial efficiency) considerations.

A static but useful measure of the annual “cost” of a transition plan can be defined as the revenue which would have been earned with no caps less the revenue earned with swing limits on a fixed, existing book of business. This cost is real and can be built into an overall rate level adjustment in order to achieve a revenue-neutral implementation of the mitigation rating plan.

One significant benefit, beyond the client goodwill and planning advantages associated with premium stability, is that new business can be written at actuarially sound rates inclusive of mitigation considerations, while renewal business can be transitioned over time to the proper premium levels. This helps minimize the competitive market distortions which would otherwise result from tempering or capping the base rates or rating factors themselves. Comparison shopping would be unaffected by considerations of whether “limited time offer” rates with insufficient refinement for mitigation would be rapidly superseded.

Some insurers may resist transition plans on systems and technology grounds, due to the need to store prior “ratebooks” or sets of rates and rating factors applicable prior to the current date. However, there is much to gain from making the effort to program rating systems to compare existing premium with renewal premium and enforce a “transition factor” which limits the premium change. Actuarial literature contains some ideas for relatively simple algorithms to manage rate calculations under a transition plan[8]. Some regulators also may be uncomfortable with transition plans in the sense that two similar risks could be charged different premiums (though not different rates) under an approved rating plan, but the situation is no different than that associated with “loyalty discounts” or similar rate discrimination on the basis of existing relationship with an insurer.

Uncertainty and Using Ranges of Rating Factors

Another option for allowing flexibility in implementation of mitigation rating plans under a mandate is to allow the various relative loss costs themselves to be set within a range of reasonable values, reflecting the inherent uncertainty in the engineering and modeling underlying the determination of the best estimates of relative loss costs. However, it is difficult to provide a statistically sound quantification of the reasonable ranges associated with each factor in the insurance benefits tables. Such an exercise could be attempted in an extension of the Study.

Recalling the discussion above about the variation in individual insurers’ books of business, the range of reasonable credits and debits, while anchored to our Study, may be something ideally discussed with the regulator and tailored to each insurer’s mix and risk profile.

[8] See Rollins, “A Modern Architecture for Residential Property Insurance Ratemaking”, Proceedings of the Casualty Actuarial Society 2005, at http://www.casact.org/pubs/proceed/proceed05/05496.pdf , pp. 545-548.

Phasing in Mitigation Rating Factors Over Time

Yet another implementation alternative which promotes a metered actuarial impact is the use of blanket "tempering" or phasing in of the chosen mitigation rating factors, with the tempering factor itself decaying over time. For example, all values in Table 7 could be subtracted from unity (1.00) and converted to credits or debits, then reduced "halfway" toward zero by multiplying by 50%. For example, a 0.86 relative loss cost from the rating example in a previous section would become (0.86 -1.00) x 0.5 = -7% premium credit instead of a -14% premium credit.

The resulting factors could be used as the credits and debits in the rating plan for a limited time, at which the tempering would be recalculated at 75% for an additional period, then fully implemented at 100% of the value in the Study. (The 50% and 75% values are solely for discussion and have no basis in engineering.) Note the Florida regulators chose a similar approach when initially implementing a mandatory residential mitigation rating plan in 2003 in that state.

Administering a Public Loss Mitigation Program

Administrative Structure and Governance

The Program could have a simple administrative structure with the Insurance Commissioner as its leader and a Program administrator handling the day-to-day functions of the oversight of the inspections, grant allocation, mitigation feature installation verification, fraud prevention and outreach. In addition, the legislatively mandated advisory board can assist in providing feedback on the Program's success as well as recommending ideas and resources for its continued successful operation.

Here are some key decision points for the MID regarding governance:

- What state agency will house and oversee the Program or will a state agency be the "overseer" with funds being awarded to local governments and/or nonprofits?
- Who will determine the responsibilities of those involved with the program?
- Who would this person report to and would existing state personnel absorb the remaining duties? If so, job descriptions and other associated documents will need to be developed.
- Partnering with outside organizations is crucial to the success of the Program. What should those organizations be and who will have the responsibility of promoting and maintaining those relationships for the benefit of the program? Is it best to have local governments directly administer the program with a Mississippi state agency overseeing the activities?
- What review and evaluation mechanisms need to be established to determine if the Program administrative structure, once it is fully established, has achieved the performance of its mission and responsibilities?

Advisory Council

The enabling law requires establishment of an advisory council for the Program including representatives appointed by MID as follows:

- One lender
- One insurance agent
- Two insurers
- One homebuilder
- One academic

And public officials as follows:

- Two Senators
- Two Representatives
- The executive director of MWUA
- The executive director of MEMA

At a glance, the balance between public and private sector participation and the spectrum of professional and technical disciplines seem reasonable. Among the insurer representatives should be at least one actuary or quantitatively product development expert who will be in a position to identify and articulate the impact of Council decisions on rates, forms, and profitability and availability of coastal property insurance. In addition, the academic should be one with a strong wind engineering and/or finance background who is in a position to understand the real-world impact of construction practices on hurricane wind insured loss reductions over time. It would be wise to look for significant insurance, modeling, and engineering expertise among the other appointees and even the public officials to be appointed as well.

Encouraging Public Access to the Program

The process Mississippi property owners use to access the Program must be simple. MID should not assume that all those interested in the program will have computers to handle the application and other issues online, so there will be a need for "call center" staff and walk-in locations for the non-wired public to be able to participate. In fact, officials should not even assume that all potential applicants will be fluent in English, and should consider multi-lingual tools within its outreach strategy.

Below is a sample Program inspection and grant process for MID to consider as a context for discussion. Issues associated with developing quality inspections and attracting grant funding are discussed further in a later section.

1. Homeowners and business owners apply online or by phone for inspection.
2. Homeowner submits by mail or e-mail, to the agency(ies) administering the Program, proof of homestead exemption if the Program is limited to homestead property. Business owners submit documentation confirming a bona fide business operation and proof of insurance documents (e.g. declarations page).

3. Inspector or inspection firm calls owner and arranges the inspection appointment.
4. Inspection is completed, owner receives copy of inspection survey checklist, and inspector returns to office to complete inspection report which is returned to the owner within 30 days. The report details mitigation improvements and estimated premium savings as required by the enabling law.
5. In grant eligible areas, homeowners receive a grant application package by mail or information to direct the owner to a website for download. A local university or a larger catastrophe modeling center could assist in prioritizing homeowners eligible for grants in hurricane-vulnerable counties by using models and software to determine, either in a static analysis or in real-time, the level of risk to that property given its geographic location and construction attributes.
6. Homeowner submits the grant application by mail or via the Internet.
7. The homeowner receives grant award letter and then selects a contractor.
8. Contractor applies for building permit – building permit application process should be expedited for this program.
9. Contractor completes work and submits mitigation verification form for homeowner to submit to insurance company for evaluation and application of premium discounts.

Partnering with Existing Public Agencies

Partnering with local governments to provide inspections and grant funds to homeowners, especially low income homeowners, can be a particular focus of the Program, although using FEMA funds for a home reinforcement program may prevent this focus (as FEMA has ruled in certain circumstances that using income as a threshold for eligibility can be discriminatory). If using FEMA funds, MID must work with FEMA to ensure compliance with its income guidelines, if any.

Additionally, partnering with local governments provides tremendous benefits, as their funding sources may be used as “match” for FEMA dollars. Eligible homeowners can sign up directly with the participating local government (city or county) and allowable improvements under the Program may be made without any out-of-pocket expenses to the low income homeowners.

Partnering with Private and Nonprofit Agencies

Should MID make the decision to be the “overseer” of the Program and partner with local governments or other organizations, it is possible that those entities can work with existing non-profit organizations to add additional leverage to the Program, as they may perform any of the improvements recommended in a homeowner’s inspection report. Working with non-profit organizations can allow leverage of contractor labor and materials at a reduced rate to maximize the number of homeowners served. The participation of non-profit organizations adds another dimension to the Program as homeowners may sign up directly with non-profit organizations in their communities, and allowable improvements under the Program can be made without significant out-of-pocket expense to the homeowners.

Management Performance Indicators

Examples of key performance indicators for reporting purposes might be as follows:

- Total calls and website hits;
- Subject types of calls – general inquiry; inspection-specific; law-related; grant-specific; assistance with grant application; local government; nonprofit organization, and so on;
- Total inspections requested;
- Total inspections completed;
- Average timeframe from inspection request to inspection completion;
- Average discount received by homeowner;
- Inspection requests received by mail;
- Inspection requests received via internet;
- Inspection requests received by phone;
- Grant application requests received by mail;
- Grant application requests received via internet;
- Percentage of grant supporting documents received by mail;
- Percentage of grant supporting documents received via internet;
- How many duplicate inspection requests and grant applications are received;
- Number of qualified wind inspectors;
- Individuals who attend wind mitigation inspector class;
- Total number of individuals who pass test per class;
- Participating contractor applicants;
- Individual grants awarded;
- Local government grant applications received;
- Local government grant applications awarded;
- Non-profit grant applications received;
- Non-profit grant applications awarded.

Consumer and Public Outreach

MID could aggressively coordinate an effort to educate homeowners and business owners on the personal, economic and social benefits of mitigation. Financial incentives are the most effective in encouraging homeowners to actively pursue hardening their homes. An example would be a sales tax exemption on certain mitigation products. Federal tax credits for home mitigation could also be promoted.

There should be clear communication on the importance of a home's hurricane rating that is characterized in a way that is easy for homeowners to understand. In addition, ensuring that there is a coordinated, comprehensive approach among public and private agencies to educate the public on mitigation can go a long way in maximizing the use of Program funds that should be dedicated to public education and awareness. To further educate those in the building profession, it is suggested that mitigation training be implemented in the general coursework provided to licensed professionals such as architects, engineers, builders, contractors and others, as part of the state's long-term strategy to ensure that wind mitigation building techniques are a part of construction culture.

Mississippi can expect to see active hurricane seasons for decades to come. The 2004 and 2005 hurricanes seasons struck fear in the hearts of citizens, with thousands of homes sustaining significant damage. Multiple hurricanes have caused sudden and significant increases in insurance premiums, which has created a financial burden on many homeowners and threatens the state's economic vitality. With this in mind, the state's strategy to harden homes in Mississippi must include consistent, assertive efforts to educate homeowners and business owners on the benefits of windstorm mitigation, including the direct impact on their personal safety, security of property and the return on investment.

There are several "moments of opportunity" that need to be seized to promote mitigation as part of a "culture of preparedness." An ideal time to encourage mitigation is when a home is bought or sold. In a 2003 statewide survey conducted by the International Hurricane Research Center, 54% of homeowners indicated that hurricane safety features were a consideration when purchasing a home. There are merits to involving the professionals involved in this transaction - realtors, financial institutions, and others - to provide information on the benefits of hardening a home against hurricanes.

There is a compelling need to communicate to homeowners the importance and impact of the state's home structure rating system. The rating system will play an important role in the affordability of property insurance, as a factor in the buying and selling of a home, and in better reflecting the value of home hardening efforts.

Lastly, to continue to engage the public, homeowners will expect to obtain the appropriate mitigation discounts or credits for which they are eligible, whether based on the current structure of their homes or due to mitigation improvements they've already made. In Florida for example, based on a statistical sampling of homes receiving services through the My Safe Florida Home program, over 50% of the homeowners on average were eligible for $220 in savings without the first nail being hammered. The average insured value of homes sampled was approximately $200,000 with an average windstorm premium of $1,500.

There are successful ways to communicate that everyone wins with mitigation: through tax notices, real estate disclosures, and notices from insurance companies. The best time to deliver the message is post-disaster or during the buying and selling of a home. Many stakeholders can help communicate, including insurance companies, insurance agents, realtors, inspectors, builders, contractors, home improvement retailers (such as Home Depot, Lowe's, and Sears), and the financial services industry. Success depends upon all avenues being employed and coordinated to reinforce the buildings of coastal Mississippi.

Brochures

Several types of brochures and tip sheets can be developed, offering general or step-by-step information about the Program, advice on making improvements and selecting contractors to make those improvements, and guidance on what insurance savings are available to homeowners based on the current features of the home (e.g. hip roof), as well as actions taken to protect the home from wind damage (e.g. installation of engineered shutters). It is recommended that MID create all brochures in multiple languages, and put all brochures on its websites and on as many other websites as possible. Example sites would be those for:

- Counties
- Cities
- State agencies
- Chambers of commerce
- Civic organizations
- Public Schools and school board
- Hospitals and healthcare facilities
- Charitable organizations
- Contractor trade associations
- Retail chains
- Construction supply vendors
- Realtors, bankers, attorneys, and other professional trade associations
- Government housing organizations
- Insurance companies
- Insurance agencies

Website design is important as well. Here are some sample headings which can used to outline the content of the Program main site:

ABOUT THE PROGRAM
PRESS RELEASES
WIND INSPECTIONS
Q&A ABOUT WIND INSPECTIONS
FOR LOW-INCOME HOMEOWNERS
HOMESTEAD EXEMPTION INFORMATION
LIST OF APPROVED INSPECTORS
LIST OF INSPECTION FIRMS/WCES
INSURANCE POLICY INFORMATION
MATCHING GRANTS

- Am I eligible for a grant?
- Q&A on Grant Process
- Q&A on Retrofit Improvements and Grants
- New Mitigation Techniques
- How to Select a Contractor
- Contractor Verification Forms for Reimbursement

FOR LOW-INCOME HOMEOWNERS
LAW CREATING THE PROGRAM
MITIGATION EDUCATION
RESOURCES
FOR HOMEOWNERS

- What Happens Next - A step-by-step guide
- User's Guide to the Home Inspection Report
- Sample Grant Reimbursement Forms

FOR WIND INSPECTORS

- Technical Bulletins

WIND INSPECTOR Q&A

- Inspector Training Classes
- Online Resource Manual for Inspectors
- Inspection Survey Checklist

CONTRACTOR INFORMATION
Q&A FOR CONTRACTORS

- Mitigation Techniques Prescribed by Mississippi Building Code

LOCAL GOVERNMENT INFORMATION
NON-PROFIT INFORMATION

A novel approach to the Program would be to create door hangers and other unique marketing materials for its inspection firms and inspector workforce (or other stakeholder associations) to distribute.

In addition, perhaps the local outdoor advertising associations could sponsor a billboard advertising campaign, and public service announcements highlighting the value of hurricane mitigation inspections and the grant program could be created. These ads could be created in Spanish and Creole or other languages as necessary.

Don't forget that working with existing mitigation organizations to use their existing educational materials on the Program website can pay dividends, by providing pertinent information and guidance to homeowners participating in the program.

Messaging

Literature, brochures and speech topics should all be focused on the central themes of the benefits of reinforcement and mitigation efforts. Without a doubt, mitigation efforts are the single most efficient way to giving property owners hope when major hurricanes threaten. Below are the central themes for messaging:

Faster Recovery: When a storm occurs, it affects not only the physical surroundings of a community but has a devastating effect on the mental health of residents in the storm's path. Damage caused by wind to homes, schools and businesses prevents many from returning quickly to these structures and when there are long delays to continuing life's normal activities, human stress results causing tremendous pain and suffering. If these structures are strengthened so that wind damage is mitigated, citizens have a greater chance of returning to life as they know it.

Better Preparedness: A strengthened structure provides citizens the ability to "shelter in place" when storms approach and make landfall. Mississippi's roadways are routinely clogged when voluntary evacuation orders are announced and citizens who can stay put contribute to less traffic congestion for those who must leave for higher ground.

Insurance Savings: Insurance policyholders who install mitigation features in their structures may receive premium discounts for doing so. Additionally, these mitigation features will reduce the amount of hurricane damage to a home, which in turn reduces insurance claims costs. Reduced insurance claims costs ultimately lead to reduced insurance rates for everyone.

In addition to the above, the following is a "handy list" of the 10 top reasons to strengthen structures:

1. Increases structure's value. Building features that increase hurricane resistance also increase its market value.
2. Reduces the likelihood to evacuate (unless ordered to do so by the authorities). Homes and businesses built or retrofitted to meet code-plus building standards can withstand hurricane force winds.
3. Improves overall hurricane recovery time.
4. Reduces the amount and extent of damage from storms.
5. Reduces out-of-pocket expenses after a storm.
6. Reduces the likelihood of an insurance claim.
7. Prevents injury from wind-borne debris.
8. Can lower insurance premiums.
9. Helps prevent damage to neighboring homes and businesses.
10. Ensures structures meet statewide building codes for hurricane-resistance.

Pilot Programs

MID should consider a pilot phase for the Program so it can test processes, evaluate the test results, then re-open or expand the Program.

Once FEMA or other funding is granted, it is suggested that a pilot Program could be launched using a Mississippi state agency as the pilot administrator covering coastal Mississippi. This pilot program could be executed regionally with a broader reach of counties if desirable. MID's leadership of the pilot program would most likely attract the interest of the Governor and other statewide elected officials which would lend credibility and momentum. MID would need to determine the best method to launch and where to locate the pilot program.

A Suggested Pilot Program: 10 Neighborhoods in 10 Weeks Campaign

"10 Neighborhoods in 10 Weeks" could potentially be the second phase of MID's home hardening/mitigation program. Hypothetically, the Mississippi Association of Realtors (MAR) could request its local chapters (perhaps 10 chapters) to identify 1 neighborhood each that would be good candidates for mitigation efforts – for example, neighborhoods built in the mid 1990's that would benefit from installation of shutters. Criteria could be established to assist the chapters with making the neighborhood selections. MAR could announce the neighborhoods, contract with a wind inspection company, devise a media campaign in the neighborhoods with local elected officials helping to spread the word, and get homeowners energized about this idea. Homeowners could receive financing from shutter companies or large "big box" retailers to offer a no or low interest loan program for shutter financing. Door knockers could be used in canvassing the neighborhoods, while encouraging the Independent Insurance Agents of Mississippi (IIAM) to sponsor spreading the word and walking the neighborhoods. Insurance company field offices could be involved in the campaign as well.

Additional Benefits of the Pilot Program

The concept of MID taking a leadership role in a hurricane wind loss mitigation program continues the work the Insurance Commissioner and the legislature have embarked upon to continue to raise the awareness of the benefits of strengthening homes.

A comprehensive strategy can be developed to pursue FEMA dollars to administer a pilot program. The support of statewide elected officials, including but not limited to the Governor, for this program will further the momentum MID can build. Continuing the state's mitigation efforts will bode well with Mississippi insurers and potentially attract those who have fled or limited their exposure back to the homeowners' insurance market.

The pilot could use the ReBuild Northwest Florida template of a matching and non-matching grant format. The pilot could also include a small effort to include certain businesses using a matching grant concept. By drawing in business, the Mississippi Chamber and the business community would potentially support and influence FEMA to support this concept.

Questions and Answers from the Public

The Program must be prepared to encounter and positively dispatch questions from a sometimes skeptical public. Here are a few sample questions and general guidelines for answers.

Q: How will you prioritize your grant disbursements?

We will depend upon the inspection report to provide the data to demonstrate that the homeowner will significantly reinforce the home if they make the improvements the report recommends. In the pilot, the data we receive in the report will be the primary component of a person's eligibility for the grant. We will check the address with a geographic information system created for us by an appropriate party, and if that homeowner lives in a priority location and the property has priority attributes, we will send the homeowner a grant application packet notifying them that they are eligible for a grant. When the grant application is returned, we will review them on a first come, first served basis. We may fine tune the process and will see what the pilot reveals over time to know where to make changes.

Q: What does "significantly" mean in your last answer?

As we start to get the reports from the wind inspectors for the pilot, we will consider whether or not to establish thresholds. Our goal is to say "yes" as many times as we can, as we are trying to change the culture of how people think about preparing for a hurricane. If they see the momentum building around mitigation and think "I must do this," we will begin to see the culture change. We are hoping to create a tipping point - just as we have made folks aware of the harmful effects of cigarettes and the importance of seat belts, we want to make wind loss mitigation a commonplace activity. In view of the huge demand and our very limited resources, our goal is to operate this program in the most equitable fashion possible - common sense will dictate how we handle exceptions.

Q: How did you come up with your numbers for the inspections and grants?

While we are offering inspections to individuals throughout the coastal counties, we will limit grants to individuals to those who live in "highest risk" areas of those counties. As I mentioned before, we use maps to link property information with "high risk" areas that we have mapped out. As a result, we can verify that a given address is within the high risk areas.

Q: What is the average time to fix a house if they need many improvements? shutters only? roof protections?

While contractors' completion times vary widely, some guidelines are as follows:

- Shutter installation: 1 day
- Windows: 3-5 days
- Roof: 2-3 days
- Multiple improvements: 1 to 2 weeks from time work starts

It is not as important for MID to script any particular answers based on this Study as it is for MID to comprehensively think through and be ready to address the most common public questions when the Program kicks off. Public attitudes and perceptions vary based on sometimes highly local demographics and experiences, particularly after the devastation of 2005.

Funding Opportunities

There are funding opportunities on several levels: existing funding at the federal and state level, structural changes to other programs to support mitigation, and development of partnerships or funding streams that are not currently in place or available.

Existing Federal Funding

At the federal level, potential funding is available to support mitigation but existing funding could be more effectively formulated to maximize residential mitigation efforts.

The Hazard Mitigation Grant Program (HMGP), also referred to as Section 404 funding, is a partnership that is designed to assist states, local governments, private non-profit organizations and Indian Tribes in implementing long-term hazard mitigation measures following a major disaster declaration. FEMA defines hazard mitigation as an action intended to reduce repetitive losses from future natural disasters. Post-disaster projects that simply repair and reconstruct damaged property to pre-disaster conditions are not eligible. Mississippi may be successful at achieving a modification that would direct a portion of this disaster-dependent federal funding to residential mitigation, such as safe rooms, home reinforcement with the features analyzed in this Study, and improvement of manufactured housing foundations. Unused HMGP funds could be allocated to counties or reallocated for statewide mitigation initiatives.

Pre-Disaster Mitigation (PDM)

Unlike the HMGP Section 404 program, the PDM program is not disaster-dependent. The PDM program is a competitive federal grant program that was created to assist state and local governments, including Indian Tribe governments and non-profit organizations, to implement cost-effective hazard mitigation activities prior to disasters that help reduce overall risk to people and property and minimize the cost of disaster recovery. In recent years, competition for this funding has been intense, but this would be a good potential source of funding for a non-profit organization or a local government desiring to establish a house hardening program.

State Housing Initiatives Partnership (SHIP)

The SHIP program is administered by states working through a statewide network of counties and specified entitlement city "SHIP administrators." The SHIP repair program is in the business of repairing low-income homes and over the years has repaired thousands of homes. Roof and opening repairs are common under this program and there is merit to including a mitigation component.

Mississippi will want to look for strategic “keystone” funding concepts and programs that would advance mitigation if funded, enhanced or aligned.

Optimizing Grants

The enabling Mississippi statutes provide that financial grants may be used to encourage single-family, site-built, owner-occupied residential property owners or commercial property owners to retrofit their properties to make them less vulnerable to hurricane damage.

The most common home improvements seen in mitigation circles include:

- Improving roof strength;
- Creating a secondary water barrier to prevent water intrusion;

- Improving the survivability of roof covering;
- Bracing gable-ends in roof framing;
- Reinforcing roof-to-wall anchorage connections;
- Upgrading opening protections;
- Upgrading exterior doors.

It is up to the appropriate officials to determine how grants should be prioritized. One method of prioritizing the use of grant funds would be to use hazard measures as a criteria. An example of hazard measures that could be used are wind speed bands, such as those shown in Figure 26.

Fraud Detection

As with any program, there needs to be a concerted effort to minimize the propensity for fraudulent or unscrupulous activity. With respect to the grants, the most common types of fraud include:

- Falsifying documents (insurance policy dec page, proof of homestead should MID determine that only homestead property is eligible) in the grant application process;
- Receiving grant funds and not using them for intended purpose;
- Installing mitigation features and then removing them for salvage or resale;
- Inflating mitigation construction estimates.

It is suggested that a team of law enforcement and housing grant professionals be put together to anticipate fraudulent schemes and to have appropriate measures in place to prevent or minimize those scenarios.

Here are some key decision points for MID regarding the use of mitigation grants:

- Should grants be limited to homeowners living in certain territories of the six-county area?
- Should grants be given on a first come, first served basis?
- Should grants be provided to homesteaded property only, or to commercial owners who reside in Mississippi and/or nonresident property owners as well?
- Should MID budget for a website where a grantee can review grant documents and/or submit receipts and documentation for MID to review?
- Should the Commissioner pursue a favorable tax ruling from the IRS for the treatment of grants? An example has been set by the My Safe Florida Home program private letter ruling from the Internal Revenue Service.
- What are the determining factors regarding priority of grant requests? What should be the hard limitations on who is eligible?
- Do we determine which homes are most vulnerable in advance of deciding on guidelines? If so, on a site-specific basis or through broad guidelines? Who is best positioned as a vendor in that effort?

- How do we encourage nonprofits and or local government (county/city) to get in the home reinforcement business?

Inspections

The enabling law requires MID to offer wind mitigation inspections to commercial property owners as well as those who reside in site-built, single-family, and 2 to 4-family residential units. The inspection report must include, at a minimum,

- A home inspection and report that summarizes the results and identifies corrective actions a homeowner may take to mitigate hurricane damage;
- A range of cost estimates regarding the mitigation features;
- Insurer-specific information regarding premium discounts correlated to recommended mitigation features identified by the inspection;
- A hurricane resistance rating scale specifying the home's current as well as projected wind resistance capabilities.

More detailed items that might be contained in an inspection report include the following:

- Identification of the property location;
- Photographs of the property and structures, validating mitigation features;
- Detailed structural information, including:
  - Use and occupancy
  - Construction type
  - Roof, including geometry, bracing, decking, covering, attachment mechanisms, and secondary water protection
  - Wall siding
  - Openings and opening protection
  - Pool enclosures or other structures that are vulnerable to wind
  - Appurtenant structures such as detached garages, fences, trellises, etc.
  - Carports, porches, overhangs, etc.
  - Number of stories
  - Area, in square feet
  - Year built
  - Year roof replaced
  - Condition
  - Building code compliance
- Neighborhood construction grading;
- Presence of unsecured materials that could become missiles, including trees and debris, gravel roofs in the area;
- Identification of initial inspector, including qualifications / accreditation and responsibility, signature and date.

Creating an inspection program which fulfills the last three requirements in "production mode" at the point of inspections will depend on some quantitative support enlisted from the construction, engineering, and insurance industries. This preparatory groundwork must be done in advance as the inspection tools are created and inspectors are trained in order to promote a successful inspection program.

For example, the ranges of cost estimates must be supported and the information available at the time of inspection in the field. Recalling our extensive discussion above on the variety of insurer rating plans in use, any insurer-specific information will require construction of specific rating examples in collaboration with the major insurers in the state. A starting point toward a hurricane resistance rating scale is simply the determination of relative loss costs for the home using this Study's approach and results. However, significant additional engineering expertise should be brought to bear if a consumer-friendly, "0 to 100" or similar rating scale is to be utilized in the field, on the fly, for homes with arbitrary attributes determined at the point of inspection.

The takeaway is that each fact offered by field inspectors must be grounded in credible study by the appropriate qualified professionals.

The inspection must be performed by a wind certification entity and hurricane mitigation inspector who reports to a wind certification entity. The entity must ensure that the inspectors:

1. Have prior residential and commercial construction or inspection experience and have received and passed (90% or higher passing test score) wind inspection training through a state certified program. Individuals qualified for the training must be a licensed building code official, licensed Mississippi contractor or inspector, or a civil engineer.
2. Have undergone (level 2) drug testing and background checks (5-panel).

Wind certification entities must also provide a quality assurance program with a "reinspection" component and have data collection equipment and processes to facilitate all stakeholders' access to the inspection data.

Inspectors as Ambassadors

The Mississippi entity overseeing the inspectors must ensure that each inspector has the necessary training and experience in the evaluation of hurricane mitigation techniques. Experience can be based on both educational training and practical experience. Experience in the residential inspection arena can be obtained from conducting residential inspections, insurance adjustments, property appraisals, engineering studies, home inspections, quality assurance evaluations for home builders, code inspections and roofing inspections.

Almost as important as training and experience is the "human" processes surrounding inspections. Those processes include understanding of homeowner scheduling constraints, communication, reporting, privacy, sensitivity and other factors that will be of great importance to Mississippi's Program.

The inspector is generally the only face to face interaction in the wind inspection and home hardening cycle. From the moment the wind inspector enters the property owner's structure until the inspection report is generated, the homeowner identifies the "Program" with the inspector. The inspector, in essence, becomes a "wind mitigation" ambassador and should do the following things to reassure the homeowner:

- Greet the homeowner with enthusiasm and thank them for taking the time to participate in the program;
- Sit down with the homeowner and briefly explain what will happen while the inspector is in the home, how long it will take, what documents will be produced as a result of the inspection;
- Ask the homeowner if there are concerns/questions about the inspection or the program, and provide the homeowner with having a toll free number or website for reference;
- Report any homeowner issues or concerns to the inspection program leadership.

Through ongoing quality assurance and training the inspection force can deliver superior performance and exceed program objectives.

Fraud Detection

Wind inspection fraud can be perpetrated by various stakeholders in the process: inspectors, property owners, insurance companies and insurance agents can all participate in the fraud where the “end game” is to try to get the lowest premium. Sometimes the competitive pressures to obtain the business can cost everyone in the long run and lead to fraudulent inspection activities. It is estimated in Florida that a significant proportion of inspection forms are fraudulent. Some fraudulent activities include:

- An insurance agent receives a mitigation form from a wind inspector that documents the best features a standard coastal Mississippi home could receive (single wraps, hip roof, new roof, gable bracing, etc.). If the mitigation documentation form is more than one page and particularly if the second page, for example, is one that contains the inspector’s signature, the agent can photocopy the second page of the mitigation form with the inspector's signature and use a blank mitigation form to fill in the homeowner's information, then attach page two with signature and submit the mitigation form to the insurer. In actuality, the wind inspection firm or inspector will have no record of inspecting the homes with the “duped” second pages.

One possible solution is to require that the homeowner’s “wet ink” signature in blue ink be on the mitigation form acknowledging that the inspector was in the home, with the homeowner’s contact information so that the insurer may spot-check validity of inspections.

- Inspectors offer "money back guarantees" to homeowners and insurance agents citing that if the property owner does not save more than the inspection price, then the inspection firm will return the inspection fee. This now creates a vested interest by the inspector to find something...anything...that will lead to discounts. For example, an inspector notes hurricane ties as roof anchorage but never inspects further to confirm that the tie goes over the truss or that ties are present on all the trusses. The inspection is completed hastily because “something” of mitigation value was present and the fee is dubbed earned and not eligible for return.

One solution is to forbid a “money back guarantee” by licensed inspectors.

- Inspection firms and inspectors encourage insurance companies and agents to use them and in return the insurer and/or agent receives a "reward." Some firms/inspectors issue the insurer/insurance agent "credits" for every inspection ordered and these credits are then used to shop an online store for “gifts.”

A solution is to prohibit this “kickback” arrangement and when detected, an example should be made of the perpetrators in the press and among law enforcement circles.

- Fraudulent use of wind inspector identification is a common practice as well. Because individuals want to be associated with bona fide inspection firms but not share the inspection fees with the inspection corporate entity, fraudulent individuals will use an inspection firm’s corporate-issued inspector identification credentials, perform the mitigation inspection, not send the inspection information to the firm and “dummy” up a report for the policyholder to use when attempting to receive the discounts. This same activity could be conducted with the improper use of a general contractor’s license credentials or other construction professionals.

It is suggested that a team of law enforcement and housing grant professionals be put together to anticipate fraudulent schemes and to have appropriate measures in place to prevent or minimize those scenarios.

Some key decision points for MID in this area include:

1. Should the selection of wind certification entities be based on ability to conduct inspections in all 6 counties?
2. Should the selection of inspection firms be based on best price offered per inspection, best price offered per inspection based on volume, or best price offered per inspection within an acceptable range?
3. What should be the basis for the number of inspections referred to inspection firms? Does MID select a number of firms and refer inspections on a rotational basis or does MID simply list the inspection firms on the website and let consumers call the entity of their choice?
4. What are the criteria for discontinuing referrals to nonperforming inspection firms?
5. Does a third party handle the reinspection component?
6. Will there be a web application to allow homeowners to download their inspection report?

Inspection Information for Homeowners

Experience indicates that homeowners who participate in the Program should receive an inspection report within 30 days. The report could include contractor bid sheets to assist the homeowner in collecting estimates for the recommended improvements. The report can provide the homeowner with a hurricane resistance rating designed to provide a general indication of how well the home is expected to perform in the event of a hurricane. The report can indicate the beneficial features that contribute to the rating and improvement plans to increase its rating based on the results of this Study.

Improvement plans provide the homeowner with the new hurricane wind resistance rating the home would receive if specific improvements are completed, the estimated cost of the plan and the estimated annual wind insurance savings.

Some decision points for MID in this area might be:

1. Should MID embark upon establishing a rating scale, and when?
2. What items should the inspection form include?
3. Should MID embrace a uniform inspection form for discounts? If so, input from many stakeholders is necessary to create uniformity and buy-in.
4. Will the state subsidize any inspections or provide any at no charge? If so, what criteria should we use to determine who gets free ones and who doesn't?
5. How many inspections do we want to conduct to show progress and accomplishment considering the total number of homes in the Study region?

Appendices

Appendix 1: Enabling Statute[9]

§ 83-1-191. Comprehensive hurricane damage mitigation program established; cost-benefit study on wind hazard mitigation construction measures; inspections; financial grants for residential retrofits; public education; advisory council; rules and regulations [Repealed effective July 1, 2009].

(1) There is established within the Department of Insurance a Comprehensive Hurricane Damage Mitigation Program. This section does not create an entitlement for property owners or obligate the state in any way to fund the inspection or retrofitting of residential property or commercial property in this state. Implementation of this program is subject to the availability of funds that may be appropriated by the Legislature for this purpose. The program shall develop and implement a comprehensive and coordinated approach for hurricane damage mitigation that shall include the following:

(a) Cost-benefit study on wind hazard mitigation construction measures.
The performance of a cost-benefit study to establish the most appropriate wind hazard mitigation construction measures for both new construction and the retrofitting of existing construction for both residential and commercial facilities within the wind-borne debris regions of Mississippi as defined by the International Building Code. The recommended wind construction techniques shall be based on both the newly adopted Mississippi building code sections for wind load design and the wind-borne debris region. The list of construction measures to be considered for evaluation in the cost-benefit study shall be based on scientifically established and sound, but common, construction techniques that go above and beyond the basic recommendations in the adopted building codes. This allows residents to utilize multiple options that will further reduce risk and loss and still be awarded for their endeavors with appropriate wind insurance discounts. It is recommended that existing accepted scientific studies that validate the wind hazard construction techniques benefits and effects be taken into consideration when establishing the list of construction techniques that homeowners and business owners can employ. This will ensure that only established construction measures that have been studied and modeled as successful mitigation measures will be considered to reduce the chance of including risky or unsound data that will cost both the property owner and state unnecessary losses. The cost-benefit study shall be based on actual construction cost data collected for both several types of residential construction and commercial construction materials, building techniques and designs that are common to the region. The study shall provide as much information as possible that will enhance the data and options provided to the public, so that homeowners and business owners can make informed and educated decisions as to their level of involvement. Based on the construction data, modeling shall be performed on a variety of residential and commercial designs, so that a broad enough representative spectrum of data can be obtained. The data from the study will be utilized in a report to establish tables reflecting actuarially appropriate levels of wind insurance discounts (in percentages) for each mitigation construction technique/combination of techniques. This report will be utilized as a guide for the Department of Insurance and the insurance industry for developing actuarially appropriate discounts, credits or other rate differentials, or appropriate reductions in deductibles, for properties on which fixtures or construction techniques demonstrated to reduce the amount of loss in a windstorm have been installed or implemented. Additional data that will enhance the program, such as studies to reflect property value increases for retrofitting or building to the established wind hazard mitigation construction techniques and

[9] Obtained at http://michie.lexisnexis.com/mississippi/lpext.dll/mscode/1c37c/1c37e/1c44a/1c44b?f=temp... 2/2/2009

cost comparison data collected to establish the value of this program against the investment required to include the mitigation measures, also shall be provided.

(b) Wind certification and hurricane mitigation inspections.
(i) Home-retrofit inspections of site-built, residential property, including single-family, two-family, three-family or four-family residential units, and a set of representative commercial facilities shall be offered to determine what mitigation measures are needed and what improvements to existing residential properties are needed to reduce the property's vulnerability to hurricane damage. A state program will be established within the Department of Insurance to provide homeowners and business owners wind certification and hurricane mitigation inspections. The inspections provided to homeowners and business owners, at a minimum, must include:

1. A home inspection and report that summarizes the results and identifies corrective actions a homeowner may take to mitigate hurricane damage.
2. A range of cost estimates regarding the mitigation features.
3. Insurer-specific information regarding premium discounts correlated to recommended mitigation features identified by the inspection.
4. A hurricane resistance rating scale specifying the home's current as well as projected wind resistance capabilities.

This data shall be provided by trained and certified inspectors in standardized reporting formats and forms regardless of the insurer involved with the property owner to ensure all data collected during inspections is equivalent in style and content that allows construction data, estimates and discount information to be easily assimilated into a database. It also ensures consistency of the program information for the consumers when dealing with more than one (1) insurance company for the comparison of services or when changing policies. Data pertaining to the number of inspections, inspection reports and consumers participating in the program shall be stored in a state database for evaluation of the program's success and review of state goals in reducing wind hazard loss in the state.

(ii) To qualify for selection by the department as a provider of wind certification and hurricane mitigation inspections services, the entity shall, at a minimum:
1. Use wind certification and hurricane mitigation inspectors who:
a. Have prior experience in residential and/or commercial construction or inspection and have received specialized training in hurricane mitigation procedures through the state certified program. In order to qualify for training in the inspection process, the individual should be either a licensed building code official, a licensed contractor or inspector in the State of Mississippi, or a civil engineer.
b. Have undergone drug testing and background checks.
c. Have been certified through a state mandated training program, in a manner satisfactory to the department, to conduct the inspections.
2. Provide a quality assurance program including a reinspection component.
3. Have data collection equipment and computer systems, so that data can be submitted electronically to the state's database of inspection reports, insurance certificates, and other industry information related to this program. It is mandatory that all inspectors provide original copies to the property owner of any inspection reports, estimates, etc., pertaining to the inspection and keep a copy of all inspection materials on hand for state audits.
(c) Financial grants to retrofit properties. Financial grants may be used to encourage single-family, sitebuilt, owner-occupied, residential property owners or commercial property owners to retrofit their properties to make them less vulnerable to hurricane damage.
(d) Education and consumer awareness. Multimedia public education, awareness and advertising efforts designed to specifically address mitigation techniques shall be employed, as well as a component to support ongoing consumer resources and referral services. In addition, all insurance companies shall provide notification to their clients regarding the availability of this

program, participation details, and directions to the state Web site promoting the program, along with appropriate contact phone numbers to the state agency administrating the program. The notification to the clients must be sent by the insurance company within thirty (30) days after filing their insurance discount schedules with the Department of Insurance.
(e) Advisory council. There is created an advisory council to provide advice and assistance to the program administrator with regard to his or her administration of the program. The advisory council shall consist of:
(i) A representative of lending institutions, selected by the Department of Insurance from a list of at least three (3) persons recommended by the Mississippi Bankers Association.
(ii) An agent, selected by the Independent Insurance Agents of Mississippi.
(iii) Two (2) representatives of residential property insurers, selected by the Department of Insurance.
(iv) A representative of homebuilders, selected by the Department of Insurance from a list of at least three (3) persons recommended by the Home Builders Association of Mississippi.
(v) One (1) faculty member of a state university, selected by the Department of Insurance, who is an expert in hurricane-resistant construction methodologies and materials.
(vi) Two (2) members of the House of Representatives, selected by the Speaker of the House of Representatives.
(vii) Two (2) members of the Senate, selected by the Lieutenant Governor.
(viii) The Executive Director of the Mississippi Windstorm Underwriting Association.
(ix) The Director of the Mississippi Emergency Management Agency.
Members appointed under subparagraphs (i) through (v) shall serve at the pleasure of the Department of Insurance. Members appointed under subparagraphs (vi) and (vii) shall serve at the pleasure of the appointing officers. All other members shall serve as voting ex officio members. Members of the advisory council who are not legislators, state officials or state employees shall be compensated at the per diem rate authorized by Section 25-3-69, and shall be reimbursed in accordance with Section 25-3-41, for mileage and actual expenses incurred in the performance of their duties. Legislative members of the advisory council shall be paid from the contingent expense funds of their respective houses in the same manner as provided for committee meetings when the Legislature is not in session; however, no per diem or expense for attending meetings of the advisory council may be paid while the Legislature is in session. No advisory council member may incur per diem, travel or other expenses unless previously authorized by vote, at a meeting of the council, which action shall be recorded in the official minutes of the meeting. Nonlegislative members shall be paid from any funds made available to the advisory council for that purpose.
(f) Rules and regulations. The Department of Insurance shall adopt rules and regulations governing the Comprehensive Hurricane Damage Mitigation Program. The department also shall adopt rules and regulations establishing priorities for grants provided under this section based on objective criteria that gives priority to reducing the state's probable maximum loss from hurricanes. However, pursuant to this overall goal, the department may further establish priorities based on the insured value of the dwelling, whether or not the dwelling is insured by Mississippi Windstorm Underwriting Association and whether or not the area under consideration has sufficient resources and the ability to perform the retrofitting required.
(2) This section shall stand repealed from and after July 1, 2009.
Sources: Laws, 2007, ch. 524, § 4, eff from and after passage (approved Apr. 17, 2007.)

Appendix 2: Example Design Calculations for roof-to-wall connection and roof deck nailing pattern

Location Characteristics:

Location: Lon = 88.88, Lat = 30.458, Zip = 39532 (Location ID = 618)

County: Harrison

Distance to Coast 2.56 Miles

ASCE Wind Speed: 137 mph (~4.8 Mi from 140 WS contour; ~11.7 mi from 130 WS contour)

Assume Window Protection per IRC. Enclosed building.

Exposure C

Building Characteristics:

Residential one-story home.

Mean Roof Height = 14 ft

Overhang = 2ft

Roof: Gable End

Slope 6/12. $\theta = 26.6$ deg.

Dimension of Building: Length = 60 ft

Width = 40 ft

Truss spacing: 2 ft o.c. (Span = 40 – 2x2 = 36 ft)

Roof Cover: Asphalt Shingle

ASCE 7-02 Calculations: Method 2 Analytical Procedure

Velocity Pressure Coefficient (Table 6-3): Kz = 0.85 for Exposure C

Topographic Factor: 1.0 No topographic speed-up.

Wind Directionality Factor (Table 6-4): 0.85

Importance Factor: 1.0

$$q_z = 0.00256\ Kz\ Kzt\ Kd\ V^2\ I = 0.00256\ (0.85)\ (1.0)\ (0.85)\ (137)^2\ (1.0) = 34.7\ \text{psf}$$

Internal Pressure Coefficient

GCpi (Figure 6-5) = Case1: +0.18

Case2: -0.18

Gust Factor (Section 6.5.8): Rigid Structure: G = 0.85

External Pressure Coefficients (Per Guide to the Use of the Wind Load Provisions of ASCE 7-02)

a: Min(0.1 x 40, 0.4x14) = 5.6 ft

Roof Component:

Effective Area = Max (36 x 4, 36x36/3) = 432 sf

Figure 6-11C

(GCp) = +0.3 For All zones

(GCp) = -0.8 For Zone 1

(GCp) = -2.2 For Zone 2

Design Pressures:

P = 34.7 x (0.3 + 0.18) = + 16.7 psf For All Zones

P = 34.7 x (-0.8 – 0.18) = - 34 psf For Zone 1

P = 34.7 x (-2.2) = -76 psf For Zone 2

Overhang pressures:

P = 34.7 x (-2.2) = -76.34 psf edge of roof

P = 34.7 x (-2.5) = -86.75 psf roof corners

Roof Panels:

Effective Area = Panel of 4 x 8 = 32 sf

(GCp) = +0.4 for Zones 1, 2 and 3

(GCp) = -0.85 for Zone 1

(GCp) = -2.2 for Zone 2 (with overhang)

(GCp) = -3.1 for Zone 3 (with overhang)

Design Pressures:

P = 34.7 x (0.4 + 0.18) = 20 psf All Zones

P = 34.7 x (-0.85 – 0.18) = -36 psf Zone 1

P = 34.7 x (-2.2) = -76 psf Zone 2

P = 34.7 x (-3.1) = -108 psf Zone 3

Fasteners:

Effective Area = 10 sf

(GCp) = +0.5 For all zones

(GCp) = -0.9 for Zone 1

(GCp) = -2.2 for Zone 2 (with overhang)

(GCp) = -3.7 for Zone 3 (with overhang)

Design Pressures:

P = 34.7 x (0.5 + 0.18) = 23.6 psf for all zones

P = 34.7 x (-0.9 – 0.18) = 37.5 psf For Zone 1

P = 34.7 x (-2.2) = 76 psf for Zone 2

P = 34.7 x (-3.7) = 128 psf for Zone 3

Roof Dead Load (ASCE 7 Chapter C3)

Asphalt Shingles = 2 psf

Plywood (1/2 in) = 1.6 psf

Trusses @ 4ft oc = 4 psf

Total = 8 psf

Design of Components:

Nailing Pattern:

Nail resistance: 8d in Southern Pine:

qr = 41 Lbf/in (NDS)

lnail = 2.5”

t member = ½ in

lp = 2.5 – 0.5 = 2 in

Cd = 1.6 (wind)

Rnail = 41 x 2 x 1.6 =131 Lb

Assume 8d @ 6” in oc interior, 6” oc edge nailing pattern. Check panel:

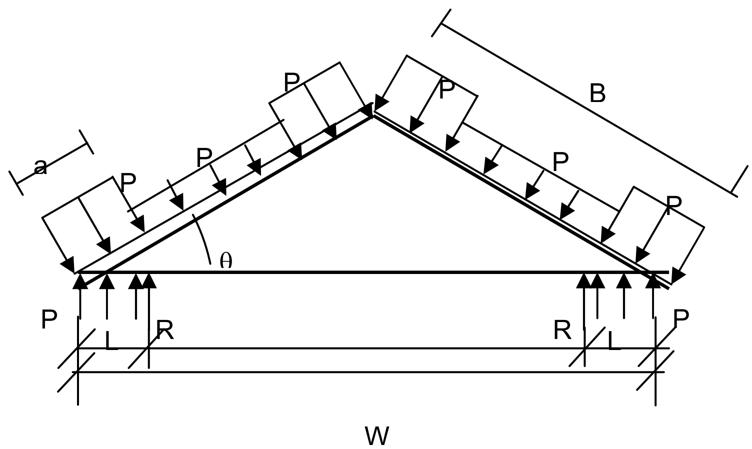
Load = 4 ft x 8 ft x (108 psf – 0.6 x 10 psf) = 3264 Lb

Nails = 2 x (4 ft / 6 in + 1) +3 x (4 ft / 6 in + 1) = 45 Nails

Panel Resistance = 131 Lb x 45 Nails = 5895 > Load Ok.

Individual Nail: Load = 0.5 ft x 2 ft x (128 psf) = 128 Lb < 131 Lb OK

Truss to Wall Connection: (Use component and cladding loading)



□M: a x P_2 x (B-a/2) + a x P_a x (a/2) – a x P_2 x (a/2) – a x P_a x (B-a/2) – R_1 x (W/2 – L_o) + R_2 x (W/2-L_o) = 0

(R_1 – R_2) = a x (B-a) x (P_2-P_a) / (W/2 – L_o) = alpha

□F_v: R_1 + R_2 = 2P_o x L_o + 2 (P_1 x (B-2a) + P_2 x a + P_a x a) x cos(□) + 0.6 DL $_{roof}$ x W = beta

R_1 = 0.5 x (alpha + beta)

R_2 = 0.5 x (beta – alpha)

For Wind parallel to ridge: P_o = 0, P_2 = P_a = P_1

Parameters:

W	40	ft	**h**	14	ft
Lo	2	ft	**B**	24	ft
a	5.6	ft	**Spacing**	2	ft
theta	0.173	rad	**DL**	10	psf

Calculations:

Case	P1	P2	Pa	Po	alpha	beta	R1	R2
Transverse Wind	-34	-76	-34	-76	-246	-2163	**-2408**	**-1917**
Longitudinal Wind	-34	-34	-34	0	0	-1395	**-1395**	**-1395**
Corner Strap	-76	-76	-76	-31	0	-3539	**-3539**	**-3539**

Capacity Required: 2408 Lb. Use Hurricane Ties. Corner hurricane ties require 47% extra capacity

About AIR Worldwide Corporation

AIR Worldwide Corporation (AIR) is the scientific leader and most respected provider of risk modeling software and consulting services. AIR founded the catastrophe modeling industry in 1987 and today models the risk from natural catastrophes and terrorism in more than 50 countries. More than 400 insurance, reinsurance, financial, corporate and government clients rely on AIR software and services for catastrophe risk management, insurance-linked securities, detailed site-specific wind and seismic engineering analyses, agricultural risk management, and property replacement cost valuation. AIR is a member of the ISO family of companies and is headquartered in Boston with additional offices in North America, Europe and Asia. For more information, please visit www.air-worldwide.com.