EVALUATING SUSTAINABLE DESIGN IN POST-HURRICANE KATRINA HOUSING

By

RACHEL JOANN COMPTON

A THESIS PRESENTED TO THE GRADUATE SCHOOL
OF THE UNIVERSITY OF FLORIDA IN PARTIAL FULFILLMENT
OF THE REQUIREMENTS FOR THE DEGREE OF
MASTER OF SCIENCE IN BUILDING CONSTRUCTION

UNIVERSITY OF FLORIDA

2011

To my loved ones

ACKNOWLEDGMENTS

First, I would like to thank my parents, Dave and Pam Compton, my brother Reid and the ever-amazing KB for their endless love, support and confidence in everything that I attempt. My accomplishments are by no means just my own- Team Compton all the way. I would also like to thank my committee for their continual faith that I could produce what I had promised. I am eternally grateful for their critique, guidance and constant encouragement. Lastly, I would like to thank Jessica Tomaselli, my “neighbor,” for her friendship, humor and constant willingness to jump in the car at a moment’s notice for a road trip. Surveying the streets of New Orleans wouldn’t have been the same without her and there is no other person that I would have wanted to travel the roads of studio and thesis with.

TABLE OF CONTENTS

APPENDIX

LIST OF TABLES

LIST OF FIGURES

LIST OF TERMS

Blight	A deteriorated condition
Building Envelope	The entire volume of a building enclosed by the roof, walls, and foundation. Properly designed, the envelope can minimize the gain or loss of heat and moisture
First Cost	The initial money required to take a material from purchase through installation. This includes actual price of material, shipping or delivery, labor and supplies to install and any inspections
Floodplain	Any land area susceptible to being inundated by floodwaters from any source
Green Building	A design, usually architectural, conforming to environmentally sound principles of building, material and energy use. A green building, for example, might make use of solar panels, skylights and recycled building materials
Hierarchy of Needs	Maslow's theory that there are five independent levels of human needs. A level may not be attempted until the levels below it are attainted. The levels are: physiological, safety, belonging and love, esteem and self-actualization
Hurricane	An intense tropical weather system of strong thunderstorms with a well-defined surface circulation and maximum sustained winds of 74 MPH (64 knots) or higher
Life Cycle Cost	The total cost to erect and maintain a structure for a given life period, including initial, maintenance and replacement costs
Storm Surge	A dome of water pushed onshore by hurricane and tropical storm winds. Storm surges can reach 25 feet high and be 50–1000 miles wide
Sustainability	Practices that would ensure the continued viability of a product or practice well into the future
Vernacular	Relating to, or characteristic of a period, place, group, or being the common building style of a period or place
Wind Speed	Wind speed is the measure motion of the air with respect to the surface of the earth covering a unit distance over a unit time

Abstract of Thesis Presented to the Graduate School
of the University of Florida in Partial Fulfillment of the
Requirements for the Degree of Master of Science in Building Construction

EVALUATING SUSTAINABLE DESIGN IN POST-HURRICANE
KATRINA HOUSING

By

Rachel Compton

December 2011

Chair: James Sullivan
Cochair: Robert Ries
Major: Building Construction

Hurricane Katrina battered the Gulf Coast in 2005, inflicting an unprecedented amount of damage in her wake, leaving life-long residents of New Orleans homeless and effectively submerging a beloved city. For a time following the storm, flurries of committees, organizations and councils attempted to plan how the city would collectively be rebuilt. While the initial plans focused on the successful recovery of the city as a whole, the reality is that in the last five years the different neighborhoods have each rebuilt in their own way and their own time.

This study surveys six New Orleans neighborhoods that endured the worst of the flooding and analyzes the recovery through a photographic field study of the exterior envelope, focusing on the existence of sustainable elements. From there, a variety of analytical tools were developed and utilized to synthesize the information gathered to identify the material selections. Sustainability, life cycle cost, durability and historical vernacular were some of the characteristics identified in the quality modeling as factors that impacted the final decision making process. Quantifying physical characteristics allowed neighborhoods to be compared to each other and to an ideal model.

Successful reconstruction of a region after a natural disaster is dependent on the community's ability to balance between the desire to rapidly reconstruct everything exactly as it was with the necessity to thoughtfully analyze the problems that the storm revealed and make the appropriate adjustments. This study aimed to provide some connection to the different factors in the decision making process.

CHAPTER 1
INTRODUCTION

On August 29, 2005 Hurricane Katrina struck the Gulf Coast and altered not only the lives of hundreds of thousands of Louisiana residents, but the dozens of industries that respond to communities after disasters have struck. One storm changed the way a city operates, a state governs and a nation responds to natural disasters. The scope of the issues that must still be addressed, six years later, are extensive and overwhelming.

A disaster is “a sudden calamitous event bringing great damage, loss, or destruction” (Merriam-Webster 2011). Disasters can be either natural or man-made, but regardless, develop in the same basic stages: creation of a hazard, activation of hazard (disaster), aftermath- where, through chain reaction, several additional systems may fail (McDonald 2003). The appropriate reactions to these stages are: preparedness, mitigation (anything that lessens the damaging effects) and both short and long term recovery management (McDonald 2003).

The most difficult issue with disaster relief and reconstruction is that the process is multi-faceted; therefore it is challenging to see each intricate part without losing sight of the whole picture. Supporting this premise, the following quote was written specifically about New Orleans post-Hurricane Katrina: “The challenges associated with rehabilitation and improvement of the New Orleans Flood Defense System need to be addressed in an integrated way combining public and social, organizational and institutional, natural and environmental, and commercial and industrial considerations. This is a “system problem” that has many parts which are interactive, interdependent and highly adaptive” (Luegenbiehl 2007). The multiple facets, as related to design and construction are largely varied in topic, but when viewed together begin to piece together the whole picture of the role of sustainable design and construction in disaster relief. As more and more natural disasters occur there is an imminent need to evaluate how the reconstruction phase is handled and whether different procedures and practices would prove more beneficial to individual residents.

Hurricane Katrina damaged an entire region of the United States, but the effects were felt on an individual level, by the people whose homes were lost, businesses destroyed, and loved ones separated. It is appropriate to analyze the impacts of a hurricane on the personal level, within the scope of the larger problem. The issues of an entire city or state are difficult to tackle, but the problems of one person, one neighborhood are manageable. New Orleans will not be rebuilt by forcing an entire city to accept new methods of construction, zoning and building codes, but rather by convincing one person at a time of the benefits of change.

Problem Statement

When a natural disaster of monstrous proportions occurs, there are typically two responses. Some are paralyzed by the sheer amount of work to be done, trying to wrap their head around the best possible solution while others react immediately, figuring that any solution is better than none at all. The opportunity to re-evaluate the collective built environment in a region also provides the chance to incorporate sustainable measures and practices into any recovery and reconstruction. Sustainability may come in the form of environmentally friendly or local materials, sustainable construction practices, or incorporating measures that increase the durability and longevity of a structure. In the case of New Orleans post-Katrina some neighborhoods were rebuilt so quickly that the lessons that needed to be learned from the storm were not, and should another storm strike, similar results will ensue. Other areas still sit in ruins, patiently awaiting the consensus of government officials and offices on the best practices for reconstruction.

Research Objectives

This study will analyze the areas of New Orleans that have been reconstructed with the intent of identifying the outcomes of design decisions. A photographic survey will provide evidence of the individual envelope systems and materials chosen. Further, analysis of the building code and typical product information will allow for Life Cycle Cost Analysis to determine if a specific factor such as first cost, hurricane readiness, or sustainability was the underlying reason for the decision. Each of the different construction systems will then be compared to the hurricane provisions in the building code and a sustainability index, with the intention of identifying if the best option for the region was chosen, or if a more suitable choice should have been selected. This will be accomplished by comparing the most frequently occurring systems in each specific neighborhood with an “ideal model” generated during the quality modeling analysis. With this information, the neighborhoods may then be compared to one another in terms of the overall success of reconstruction and how the individual residents are recovering.

Significance

The studies found on the topic of Hurricane Katrina and the New Orleans responses have predominately each focused on one portion of the recovery process, be it population displacement, the reconstruction of one neighborhood or house, or the hurricane requirements for building materials. This study attempts to bridge the gap by viewing the problem not as a segmented one, but rather as a comprehensive and complicated one, weaving between industries, genres, generations and social classes. The answers must do the same.

Of the Place

New Orleans is a city steeped in tradition and history, proud of who it is and how it got there. The city itself is built like a tapestry, with centuries of layers woven together to give it the character it is widely known for. Many of its residents have lived there for their entire lives; their families for generations. For the recovery process to be deemed successful, it must respect the history of the buildings, the city structure and the methods that the residents use to interact amongst themselves. “Buildings and their neighborhoods were the setting where New Orleanians defined their identity, developed their customs and rituals, and understood their sense of place” (Kingsley 2007).

Of the Storm

A city going through the massive reconstruction that Hurricane Katrina necessitated cannot help but have some threat of a crisis of identity. The ability to update and enhance the problematic features of the city threatens to alter its personality permanently, as does the input of individuals from across the country, with their own opinions on the best methods to enhance the built environment.

This study looks at a variety of neighborhoods in the New Orleans Parish, some of which have been reconstructed with only local assistance, others with national involvement. It should become apparent through the analysis which areas have successfully remained solely “New Orleans” and which have welcomed expansion and further development.

Limitations

The scope of this study limits research to general topics concerning natural disaster recovery and reconstruction, with a specific focus on hurricanes. The only disaster thoroughly dissected and analyzed was Hurricane Katrina, while New Orleans, Louisiana was the only impacted city reviewed in person. For research purposes, Hurricane Andrew was referenced in relation to the building code. For the purposes of this study, the Florida Building Code was used exclusively to not only set the standard for hurricane readiness but also as the criteria against which the New Orleans residences were compared. The reasoning for this is two-fold. Firstly, as discussed below, the building codes in the United States are not nationally ratified, but rather determined and enforced on a city, county or state level. Louisiana does not enforce building codes statewide, which presented a problem since the focus zone was the greater New Orleans area. Secondly, since this study is only concerned with the building code in relation to hurricane readiness, Florida is widely considered the strictest code concerning hurricanes. Reasoning followed that using it as the comparison benchmark would provide recommendations for building systems that would most hopefully hold up in future storms.

CHAPTER 2
LITERATURE REVIEW

Overview

The purpose of this study is to conduct an analysis on the exterior envelope of residences in an effort to identify sustainable measures implemented after a natural disaster. The background information needed to accomplish such an act is vast and covers a variety of subject areas. The following review of the literature encompasses:

- Types of natural disasters and the potential impacts on the built environment
- Individual response to natural disasters including population displacement, new and restorative construction, preserving history and insurance
- Potential impacts on the construction industry such as a comparison of sustainable construction and sustainable design, the differences between traditional and sustainable construction, designing disaster-proof buildings and the necessities of building to a more stringent building code
- A case study of New Orleans and Hurricane Katrina, specifically focusing on the events of the storm, Louisiana architecture and the reconstruction response to date
- The span of analytical tools that were utilized in the methodology to execute the field study and subsequent analysis

Each section of the literature review was compiled for its relevance not only to natural disaster recovery, but for the New Orleans area. Not all sections were explicitly related to sustainability, but in those instances the relation was noted and the connection identified.

Types of Disasters

As the built environment increases in complexity, so must the measures necessary to ensure the safety of the occupants in all weather situations. For the purpose of this paper, research is limited to disasters that are natural, or in some cases labeled "Acts of

God”. This category includes hydrological (hurricanes), geological (earthquakes) and meteorological (tornadoes).

Hurricanes are low-pressure systems that form into tropical cyclones in the western hemisphere (cyclones in the eastern hemisphere are referred to as typhoons) (FEMA 2011). These storms occur close to the equator, in warm, tropical waters and are classified into five categories depending on wind speed, damage potential and central pressure (FEMA 2011). Hurricanes only occur in the Atlantic during a specific time of the year (June to November) when ideal conditions for the storms exist and are named for easy identification (McDonald 2003). These conditions include warm, humid ocean air evaporation, convergence of surface and high altitude winds, and the difference in surface and high altitude wind pressure (McDonald 2003). The threats of a hurricane include flooding, tornados, storm surge and high wind speed (reaching up to 155+). Hurricanes that are generated north of the equator have an eye that spins counter clockwise, with wind bands that spin opposite. The factors of destructiveness are wind speed and storm surge, while the extent of damage is dependent on the angle the hurricane hits, the strength of the storm when it makes landfall and the side of the hurricane that comes ashore first (the right side of the storm is significantly stronger) (McDonald 2003). The threats of a hurricane include flooding, tornados, storm surge and high wind speed (reaching up to 155+).

Earthquakes are defined by the Federal Emergency Management Agency (FEMA) as “ground shaking caused by sudden movement of rock in the Earth’s crust” (FEMA 2011). This movement occurs along faults, or cracks in the crust and releases energy that causes seismic waves, or vibrations (FEMA 2011). The earthquake itself can last from seconds to several minutes and occur year-round. They are a result of the release of the stress that builds as a result of the friction between tectonic plates that attempt to move beneath the Earth's surface (FEMA 2011). Earthquakes are measured in magnitudes on the Richter scale, from one to ten. An earthquake that measures a five on the scale will begin to cause damage to infrastructure (Richter Magnitude Scale 2011). People can be impacted in a multitude of ways: landslide, surface faulting, tsunamis, liquefaction (where "loosely packed, water-logged soils temporarily lose strength and stiffness and behave like liquids, causing the ground to sink or slide"), and flash floods (FEMA 2011).

Tornados are the most violent of natural storms and occur with little to no warning. They are typically the result of thunderstorms, but may also accompany hurricanes. Winds can reach up to 300 mph and strike land arbitrarily, with a path that can reach one mile wide and fifty miles long (FEMA 2011). Tornados typically strike the middle of the eastern United States, in an area that is referred to as Tornado Alley.

The only type of natural disaster addressed in this study will be hurricanes, specifically Hurricane Katrina. The purpose of examining other instances of natural disasters is to provide evidence of one simple fact: out of all types mentioned above, hurricanes are the only instance when residents have warning. Not only can the National Weather Service provide a rather predictable path of destruction, but mathematics allows for the severity of the storm to be predicted prior to impact. As with all sciences, nothing is guaranteed and hurricanes have in certain instances acted contrary to the norm, but the window of warning allows for preemptive measures to be taken to ensure the safety of the population and the survival of code-compliant infrastructure.

Additionally, the discussions of earthquakes and tornadoes provide a frame of reference for the intensity of the scientific elements discussed in relation to hurricanes. Architects and construction managers have managed over time to develop methods to protect the built environment from the elements of tornadoes, hurricanes and earthquakes. Ideas generated to solve earthquake and tornado issues may be adapted to work for to make shelters more conducive to surviving hurricanes, which in turn makes them more durable and in some instances, sustainable.

Consequences of Hurricanes

Flooding

Flooding is one of the major dangers associated with hurricanes. Not only can the water present a danger of drowning, contaminated water spreads disease and destroys physical property. Flooding can be caused by a variety of means: hurricanes, melting snow, tidal activity and dams (or levees) breaking (McDonald 2003) and can occur either by slowly building up, or in a flash flood (FEMA 2011). Flash floods are defined by the Federal Emergency Management Agency as floods that “often have a dangerous wall of roaring water that carries rocks, mud, and other debris and can sweep away most things in its path” (2011). Flash Floods can occur without rain or as a result of a breach in a water management system (like a dam or a levee) (FEMA 2011).

Floods are the most frequently occurring natural hazard (FEMA 2011) and account for the most damage and highest death toll (McDonald 2003). All regions are at risk of floods, although the severity of the floods is determined by several factors: amount of water, absorbency of land, flood relief systems, presence of levees and dams, and excessive water occurring along the coastline (McDonald 2003). Damage to buildings can be created by mud and water residue, and unless properly air dried, mold can spread quickly and is only removable by replacing the impacted section of a structure. Two methods exist to protect structures from flood damage: dry-proofing and wet-proofing. Measures taken to keep water out of a building are considered dry-proofing, while wet-proofing aims to improve the ability of building components to withstand the effects of water (McDonald 2003).

Wind

Wind is the constant movement of air between high and low pressure areas (McDonald 2003). Wind by itself does not typically result in large-scale damage, but the wind that is generated from hurricanes can create tornadoes as the storm makes landfall. Winds can damage buildings if they exceed wind loads, which are the "effect of wind force acting on a building," or by flying debris (McDonald 2003). The effects of wind on structures include pressure and suction on roofs and walls, lateral pressure on solid and framed walls and uplift forces on foundations (McDonald 2003). Wind damage during hurricanes can often be avoided by following the most recent building code and paying additional attention to the fixings and fastening details (McDonald 2003).

Impacts on the Individuals

The research revealed that information relating to disaster relief and construction has been gathered and presented in two scopes: that of the individual and that of the industry. The aftermath of the disasters happens to people- houses are destroyed, jobs suspended or eliminated and years of work are needed to restore the dynamics and character of an area.

Effects on Population and the Built Environment

The article “Population Displacement and Housing Dilemmas Due to Catastrophic Disasters” brings to light the daunting period between immediate shelter and permanent housing that is often overlooked (Levine et al, 2007). Post-Katrina it became apparent that at times victims will have to recover far from the disaster site which can lead to greater feelings of displacement (Levine et al, 2007). Additionally, each state is responsible for their own laws relating to emergency plans, which creates a wide disparity when trying to establish a universal plan for disaster management (Levine et al, 2007).

Temporary housing is another concern when it comes to hurricane recovery and reconstruction. Traditionally, temporary housing consisted of trailers, which leave residents vulnerable in the instance of an additional storm. Hurricanes are occurring more frequently and with more strength. Reports indicate that the losses suffered in the United States in the last twenty years are on the same scale as underdeveloped countries (Levine et al, 2007). The reality is that more people are displaced with each storm, and the desire for safe, quickly assembled housing has become a pressing necessity. The Katrina Cottage was established in 2006 as a small shelter that was strong enough to withstand hurricane strength winds, portable enough to reside on the owners land while the reconstruction occurred, and had the ability to be repurposed as a guest house once recovery was complete (Levine et al, 2007). Initially, the house was rejected by FEMA as a result of the potential permanency of the structure, until the decision was overturned by Congress (Levine et al, 2007).

The built environment has a documented impact in the emotional and physical well-being of an individual (Kopec 2006). A residence meets both physiological and safety needs in Maslow's Hierarchy of Needs, which are considered the most basic of needs (Kopec 2006). Interestingly, humans are notorious for forming emotional attachment to physical structures as well as the safety and security they provide (Kopec 2006). In most instances a house "comes to resemble or represent who we are; provides a sense of connection to other people, our pasts and our futures; provides both physical and symbolic warmth and safety ; and is physically suitable for our physical and psychological health" (Kopec 2006). The study of how humans interact with the built environment and the ultimate impact of this interaction is known as environmental psychology. One theory that is applicable in the context of natural disasters is the interactional theory, which promotes that people and the environment are two individual entities that constantly interact with one another, while the organismic theory contends that "social, societal and individual characteristics intertwine with the environment in a complex symbiosis" (Kopec 2006). These factors, with the environment, can produce particular behaviors (Kopec 2006).

People, who have been displaced by a natural disaster, tend to migrate as a survival strategy, to deal with the "prospect, impact or aftermath of disasters" (Oliver-Smith 2006). A tremendous amount of the population of New Orleans was forced to temporarily relocate, but as of early 2011, the population was still down almost 30% from pre-Katrina census numbers (Saenz 2011). Many of the residents who have returned waited until 2009, when businesses began to reopen (Saenz 2011). Two of the concerns of planners and policy makers are that the return of residents prior to an executable city redevelopment plan will result in urban sprawl and premature re-growth (Levine et at, 2007). Both of these issues can result in structures being built on ground that does not meet code requirements or in areas where the general infrastructure is already stressed (Levine et al, 2007). The impact of these two factors is felt in more than just the built environment. One recommendation of Levine is to prioritize keeping communities together, to ensure that their social and economic networks remain intact (Levine et al, 2007).

When analyzing the causation and end results of a natural disaster, it is easy to look only to the physical aspects of a region that fail. In the instance of Katrina, this would be the line of thought that the hurricane caused flooding, which breached the levees, thereby flooding the city and displacing residents. The problem that results from this type of thinking is that it ignores the social issues that are magnified in times of disaster (Myers et al, 2008). “Disasters are fundamentally social phenomena; they involve the intersection of the physical process of a hazard agent with the local characteristics of everyday life in a place and larger social and economic forces that structure that realm” (Bolin 1998). In Hurricane Katrina this theory manifested itself in the disproportionate amount of rental and low income housing that was severely damaged or destroyed and the number of elderly that lost their lives as a result of lacking the means to evacuate (Finch et al, 2010).

For the purposes of this paper, the investigation will focus on the physical ramifications of the hurricane, but it would be remiss not to acknowledge that social factors contributed not only to the damage sustained but also to the pace with which the reconstruction efforts were executed.

Insurance

Perhaps one of the most worrisome aspects of dealing with the aftermath of natural disasters and reconstruction is that of insurance. In recent years, the surge in disasters has all but decimated the insurance industry, leaving individuals unable to rebuild. The article by Howard Kunreuther, “Reducing Losses from Catastrophic Risks through Long-Term Insurance and Mitigation” (2008) reviews the changes that insurance is going through and offers some solutions and insights into ways to benefit both the industry and the individual alike. Prior to the 90s, the insurance industry averaged an annual payout of $4 billion relating to natural disasters (Kunreuther 2008). Katrina alone cost the industry an estimated $46 billion, while the four hurricanes that hit Florida in 2004 cost $33 billion (Kunreuther 2008).

Hurricanes present a unique issue for both the insurance industry and the owner of the damaged property. Damage inflicted by hurricane wind is covered under the general homeowner’s policy, but flood damage is not (Pasterick 1998). Flood damage insurance is available through the National Flood Insurance program, which is coordinated by FEMA (Pasterick 1998). Congress manages the insurance rates, but some restrictions do apply, such as the development of community flood maps and the enforcement of minimum building codes (Pasterick 1998). NFIP covers both coastal and riverine floodplains, and offers reduced rates to communities that comply with additional protection and mitigation guidelines (Schwab et al, 1998).

The article offers two factors for why the losses have seemingly increased so drastically: the degree of urbanization (developing Florida for retirees) and value at risk (Kunreuther 2008). “Significant amount of damage would be averted if wind and seismic building codes were adopted and enforced and if individuals took protective measures in advance of possible disasters” (Kunreuther 1998). The insurance industry has had a difficult time convincing residents in disaster-prone regions of the benefits of mitigation, due in part by the belief of residents that they themselves will not be the victims of this type of situation (Kunreuther 2008). In the case of New Orleans, many of the areas most drastically affected were in rent-prominent neighborhoods. Most often the decision to insure or not, and to use mitigation measures or not is the product of balancing the anticipated benefits with definite costs (Pasterick 1998). Individual beliefs and additional factors (probability, cost, lack of knowledge) contribute to individuals not analyzing the cost benefits of precautionary measures (Pasterick 1998). The recent influx of severe storms has put strain both on insurers and residents. Some companies are experiencing difficulty recouping their losses, thereby increasing their costs and standards, making it more difficult for residents to qualify and afford insurance (Kunreuther 1998).

The most plausible solution offered by Kunreuther is that of long-term homeowners insurance, which would operate similar to a mortgage and be attached to the property rather than the occupant, allowing for transfers as necessary (2008). The bottom line is that if natural disasters continue with the intensity and devastation that has occurred in the last decade, then the insurance industry will have to make some changes to be able to continue to offer coverage to residents in high-risk areas (Kunreuther, 2008).

New and Restorative Construction

Many factors are involved in reconstructing a community after a natural disaster and often the focus is on action, progress, and getting things accomplished that the most important factor is forgotten: the people. When focusing on the big picture, it is easy to forget that the picture is made up of thousands of individual lives, lives that will be impacted by every decision and action that is made. In the article “Healthy Homes and Communities: Putting the Pieces together", the authors stress the importance of involving community residents in the planning process (Miller, Pollack and Williams 2011). "Participating in and sharing control of important events affecting their lives might be especially key for socially disadvantaged individuals, who have few opportunities to weigh in on such matters and cannot prevent undesirable events or bring about good thing[s]" (Miller et al, 2011). While the previous quote refers specifically to socially disadvantaged individuals, it is reasonable to make the connection to recent victims of natural disasters who have also lost a sense of control over their surroundings. The act of participating in the reconstruction allows for some normalcy to return. Often times, the individual will provide a better perspective on the importance of issues and be able to clarify for officials where the reconstruction focus should be directed.

The issue of who to blame when buildings fail is complex and impossible to determine. Many factors enter into why a building fails and many different companies and entities participate in the construction of a city. Some individuals believe that it is not productive to access blame and while that is often true, it can in fact be a useful exercise to examine why something failed (Luegenbiehl 2007). The article "Disasters as Object Lessons in Ethics: Hurricane Katrina" evaluates the situation in terms of engineering, but many of the conclusions the author arrived at are applicable to all parties involved in construction (Luegenbiehl 2007). Reviewing the parts of a project that failed often generate the most creative solutions to fix the problem, because the urgency that something different must be done spurs out-of-the-box thinking (Luegenbiehl 2007). It is also critical to remember that design and construction isn't just about the physical structure, especially when rebuilding an area that has been lost; political, historical and cultural factors also need to be taken into account (Luegenbiehl 2007).

Sustainability can be a factor in both new and restorative construction. New construction projects provide ample opportunity to incorporate structural systems, material finishes and construction site practices that promote green design and a healthier environment. In contrast, restoring solidly built structures to increase their durability and longevity is another form of sustainability that will be further reviewed in the following section on historic preservation.

Preservation of Historic Architecture

One component that must be considered when deciding between new and restorative construction is that of the historical significance of the site(s) in question. Historic preservation is defined by the Advisory Council on Historic Preservation (ACHP) (2011) as the “preservation, enhancement and productive use of our nation’s historic resources.” The ACHP is an independent federal agency that works in conjunction with the governor-appointed State Historic Preservation Officers, who are responsible for maintaining the National Register of Historic Places (ACHP 2009).

Historic buildings are particularly susceptible to damage caused by hurricanes. The force of the storm can weaken the structure, alter the ground conditions and morphologically alter the building materials (McDonald 2003). Damage from floods can exist in four different forms: standing water results in mud residue and dampness inside the building, sudden bursts of water can result in mechanical damage, flowing water can carry foreign objects such as debris and oil inside and sea and brackish water often results in salt damage (McDonald 2003). The high-speed winds associated with hurricanes can inflict roof damage by suctioning off the roof, or increasing pressure on the interior until the building in essence, explodes (McDonald 2003). The damages just mentioned are similar to the damage inflicted on a modern structure, the difference with a historic building lies in how it must be repaired. Typical modernizations can potentially compromise the structure of a historic building, but some measures can be taken to strengthen the building prior to a disaster including: underpinning foundations, increasing ties on roof, foundation and exterior walls, and strapping structural members (McDonald 2003).

Historic preservation is a critical issue to consider when reviewing the reaction and recovery of New Orleans post-Katrina. The city has long been known for its unique architecture and city ambiance, a testament to the original roots of the first settlers. Louisiana was the first American region to explore the variations of the shotgun house that it is now synonymous with. The specifics of the architecture will be discussed later, but it is important to note here that the late 19th and early 20th century architecture is as beloved and closely associated with the city as any of its other festivities.

Katrina's impact on the historic community was severe. Four weeks after the storm, the New Orleans mayor suspended the authority of Historic District Landmarks Commission, thereby allowing thousands of buildings in the historic district to be demolished without the proper review (Verderber 2009). In 2008 the city passed an ordinance that allowed the demolition of buildings that were deemed an 'imminent health threat' to the community as a whole (Krupa 2008). The need for this type of ordinance is understandable, however it seems that the precautionary thirty-day waiting period necessary to discourage the abuse of the ordinance was not enforced (Verderber 2009).

Impacts on the Construction Industry

While the aftermath of the disaster impacts the individual, it is the industry that is responsible for putting the pieces back together. The recent increase in yearly natural disasters as well as the global push for sustainability forced players in the construction industry to re-examine their practices and methods in hopes of refining their processes for the benefit of both the companies and the individuals.

Sustainable Construction versus Sustainable Design

The differences between sustainable construction and sustainable design are subtle; sustainable construction deals with the methods, materials and processes that are involved in the physical construction of a structure while sustainable design occurs in the planning of the structure. This definition is based primarily on the pre-determined responsibilities of designers and construction managers. That said, each party impacts the sustainability of the other, and in all situations a building will not be "green" without the cooperation of both parties. "Design can be defined as the intentional shaping of matter, energy and process to meet a perceived need or desire. It is the hinge that inevitably connects culture and nature through exchanges of materials, flows of energy and choices of land use. In many ways the environmental crisis is a design crisis. It is a consequence of how things are made, buildings are constructed and landscapes are used" (Van der Ryn and Cowan 1996).

For the purposes of this paper, sustainability is typically thought of as environmentally friendly measures or systems that are installed on or into the building. In a broader sense, sustainability can also be thought of as the potential longevity of a structure. Applying this definition to recovery and reconstruction will “give residents of disaster-prone areas a sense of security and preparedness” (Gopalakrishnana and Okada 2007).

Integrated design

The difficulty of distinguishing between sustainable construction and design is telling in itself. The responsibilities for these two processes have been split for decades, to the detriment of the built environment. Construction and design are both necessary to create one cohesive building, which is difficult to accomplish when all participants are not on the same page. The green building movement has brought with it a resurgence of integrated design. Sustainability is accomplished by utilizing opportunities in buildings to reduce waste and optimize complex systems. Often “the most significant challenge to delivering a financially successful green project is communication and coordination across a multidisciplinary team” (Robichaud and Anantatmula, 2011). When a team that represents all major components of the building, i.e. architecture, construction, engineering, landscape, interiors, ecology, finance, and business is compiled at the beginning of the design process, then issues can be worked out early, while the design is evolving. Traditionally, the design of a building has followed a linear structure, where each discipline does their work and passes the project to the next person. An integrated approach allows the design process to work at its best: in a cyclical manner where continuous iterations allow for each discipline’s adjustments to be absorbed into the design. Once all issues are resolved, the process can resume a linear process which works best in construction. This method of integrated design is quite possibly the “only effective approach for creating comprehensive green buildings on a reasonable budget” (Malin 2004).

Sustainable design

One aspect of sustainable design that sets the tone for the entire project is the site selection and the decision whether or not to incorporate vernacular design features (Oktay 2001). Historically, different regions across the United States developed traditional building methods (also known as vernacular architecture) that responded successfully to the specific climactic conditions that the region had to contend with (Oktay 2001). Specific elements that relate to vernacular design include: aesthetics, over-shading, self-shading, vegetation, pollution and positioning of the sun (Oktay 2001). Design should always relate first to the user and the environment because “architecture is a dynamic adaptation to place, people and pulse” (Van der Ryn and Pena 2002). Well designed buildings have been cited with increasing productivity and the general health of the users, thereby impacting both the physical and psychological needs of humans (Van der Ryn and Pena 2002).

Sustainable construction

Many sustainable construction techniques were mentioned in the previous section on traditional versus sustainable construction. In addition to the sustainable materials that were mentioned above, there are also sustainable practices (or ways to perform the construction without negatively impacting the environment) that may be implemented (Robichaud and Anantatmula 2011). Sustainable construction practices can reduce energy consumption and lessen the disturbance made to the natural systems that exist on and around the site (Robichaud and Anantatmula 2011).

Traditional versus Sustainable Construction

Sustainable construction is defined as “creating and maintaining a healthy built environment based on ecologically sound principles” (Kibert 2002). One of the easiest ways to build sustainably is by using alternative materials. Not only do buildings consume 40% of the earth's energy resources, they are also responsible for 40% of the processing of raw materials (Swan et al, 2011). Examples of alternative materials include straw bales, earthen construction and precast concrete. Both straw bales and earthen construction utilize material resources that are historically sound and the by-product of another process (Swan et al, 2011). The main hindrance to these methods is public perception. As a result of ignorance, these methods are believed to produce inferior structures. This opinion can be changed by the inclusion of these techniques in building codes (Swan et al, 2011). The instances in which alternative materials are applied are not always readily available, but these unconventional materials may offer the increased structure necessary to withstand storms, thereby increasing sustainability two-fold: in the material itself, as well as in the longevity of the building.

Precast concrete is an alternative to cement block that reduces the amount of waste generated by the project (Baldwin et al, 2009), shortened construction time, increases productivity and improves safety records (Chen et al, 2010). Panels are cast in a factory and then transported to the building site. Precast panels are less labor intensive than traditional materials, allow for better quality control, are safer to produce, and allow for more intricate detail to be used (Baldwin et al, 2009). Downsides to this option are longer lead times and higher costs for smaller projects (Baldwin et al, 2009).

Sustainable construction includes more than just the materials that are used in the structure. The construction and material industries often only look to the final product to determine how "sustainable" it is. This leaves out all of the steps and processes that occur before that final realization. Emergy is a term used in construction ecology that encompasses “the energy that was required and used to make a product or service; its embodied energy” (Kibert 2002). Significant amounts of emergy are required to concentrate fossil fuels and non-renewable resources that are used to expand the built environment (Odum 2002). When working with emergy, the amount of energy used to extract, refine and transport materials to a construction site must be taken into consideration, which encourages a more holistic view of a material’s sustainability. Utilizing local materials reduces emissions and the costs associated with transportation, but the materials are more likely to have been harvested locally and be more apt to endure region-specific weather conditions; vernacular architecture is a useful indicator of which materials are the best choices (Morel et al, 2001). Earthen construction was mentioned previously, as an alternative material choice. The structure can also be designed and built into the ground (this technique offers significant protection from natural disasters, such as hurricanes) with the earth being removed for the building utilized for the wall construction, therefore eliminating all waste and reducing costs (DOE 1997).

Regardless of the benefits to both occupants and the environment, sustainable construction is still dependent on the ability to be financially competitive when it comes to being chosen over traditional construction methods. Sustainability is often thought of solely for its environmental impact, but industries must also incorporate economical, societal and personal implications (Berns et al, 2009). Three factors that might hinder the acceptance of sustainability in construction include: benefits are experienced long-term and often there is no immediate return on investment, effects of sustainability are wide-reaching, over multiple systems and industries and therefore difficult to forecast, and lastly impending changes in national practices and regulations make strategic planning difficult (Berns et al, 2009). The natural materials utilized in sustainable building and construction are often low in cost, but labor intensive to install (Piepkorn 2005).

Additionally, sustainable building techniques often have a difficult time meeting current building codes, simply because there are not often provisions for alternative construction methods (Piepkorn 2005). The International Code Council had developed a code that provides performance provisions as opposed to outlining allowed methods and techniques (Piepkorn 2005). The final say in whether a method is allowed, though lies in the local government and enforcement office, which retains the right to require materials testing by accredited facilities as well as engineering studies (Piepkorn 2005).

Design and Disaster-Proof Buildings

The idea of a disaster-proof building is rather an oxymoron. Referencing the earthquake in Haiti (in 2010) that devastated the country and was responsible for hundreds of thousands of deaths, Sarada Sarma said “we cannot stop structure failing, but we can make sure that they fail safely. We can pinpoint the damage in different parts of the structure for example, the columns should not fail, let the beams fail instead. If the beams fail, people will have time to get out” (Thomson 2010).

The article “Infrastructure Design Issues in Disaster-Prone Regions” identified three issues with the current building standard in relation to designing for disasters (Guikema 2009). The first was an assumption that the standardized code has struck the proper balance between benefits and costs of different alternatives for multiple types of buildings (Guikema 2009). Secondly, design decisions should not include the life cycle impacts of certain systems, and lastly, that the incorporation of natural systems would not add protection to a design (Guikema 2009).

With the recent increase of natural disasters several industries that are impacted have responded. Products and technologies have been developed to increase the strength of structures, including everything from high-impact roofs to impact resistant glass to installable safe rooms (Queena 2004). One material that is experiencing scrutiny right now in relation to New Orleans is concrete (ENR 2006). Since the devastation of Hurricane Andrew, concrete has found a lucrative market in Florida homes and may be the affordable, safe option that Louisiana is looking for (ENR 2006). The material has undergone some scrutiny because it cannot duplicate the vernacular aesthetic that New Orleans is known for, but according to the Home Builders Association of Greater New Orleans president Toni Wendel, “as long we can get them up safe, cost-effective and up to code, our mission is to provide affordable, safe housing to the consumer” (ENR 2006). The only factor that might prove challenging in dealing with New Orleans is the foundations, since the soil is not ideal for concrete construction (ENR 2006).

No building will be completely disaster-proof, and unfortunately the building code has not always been written to preemptively avoid structural failure- more often than not the necessary changes to the code are implemented during the recovery and restoration period after a disaster. Truly designing a disaster-proof house incorporates factors from all of the previously mentioned sections, selecting the best options from each industry and insuring that the systems all work together to prevent structural failure. The recent surge in natural disaster occurrences has spurred state governments to heighten building code minimums and insurance companies to brainstorm on the best ways to proceed without going bankrupt.

Building to More Stringent Code

When dealing with tornadoes, very little can be done in advance to build a building that can withstand the force that will be exerted on it. However, with hurricanes and earthquakes designing to stricter building codes can help the structures to endure. In the past, the thought process has been to focus designing codes to everyday issues, rather than focus on things that have a one-in-a-million chance of happening. When this approach is taken with the majority of decisions, though, the chances begin to compound and instead of being a chance, the breakdown becomes inevitable. This is what unfortunately happened with the levees in New Orleans during Hurricane Katrina.

An article published just after Hurricane Ivan struck in 2004 addresses the issue of Louisiana being potentially vulnerable to damage. The question that was posed was if stricter codes would in fact decrease amount of damage when a hurricane hit (Sawyer et al, 2004). With large storms reported to be occurring more frequently, officials are being required to not only look at the evacuation plans of communities but also how future construction techniques need to adapt and where limits should be placed on costal building (Sawyer et. al, 2004). The article, which was written prior to Hurricane Katrina, calls out New Orleans as vulnerable, with Army Corps of Engineers' senior project manager Albert Naomi citing that "The city's levee system is adequate for 90% to 95% of likely storms, 'it's the other five to 10% that scares me'" (Sawyer et. al, 2004).

The problem that the levees presented was that they were in fact adequate for up to 95% of storms, making it difficult to justify the time and expense to repair them before there was an imminent need (Sawyer et al, 2004). Florida building codes are currently considered the strictest code relating to hurricanes, and the buildings that are being built to that code are surviving the storms with manageable damage (Sawyer et. al, 2004). The older buildings that were built prior to the code update following Hurricane Andrew in 1992, however, are sustaining devastating damage (Sawyer et. al, 2004).

Specific techniques for hurricanes that are requirements in the Florida Building Code include impact resistant doors, windows and walls, connectors that allow the load from the wind to travel from the roof to the ground, and exterior lighting that is made from laminated, tempered, toughened glass to prevent shattering (Hadhazy 2011). For tornados, safe rooms made of steel or concrete can decrease injuries and deaths (Hadhazy 2011). The same connectors that are required for Florida houses are also applicable for houses in the region most frequented by tornados, Tornado Alley (and in earthquake zones) but are not required by the building codes (Hadhazy 2011). Building codes in California are among the most stringent (in relation to earthquakes), not only requiring the connectors and reinforcing of columns, but in some instances utilizing what is referred to as “base isolation,” where the base acts as a shock absorber (Hadhazy 2011).

Case Study: Hurricane Katrina

Events

Hurricane Katrina is one example of a recent natural disaster that decimated a region. The direct property losses were estimated at $30 Billion with 78% of the losses in residential areas (Link 2010) and economic losses have topped hundreds of billions of dollars (Petterson et al, 2006). Eighty percent of New Orleans was under water, many depths reaching 20 feet (NOAA 2005). Over 1700 people were killed and hundreds of thousands were displaced for extended periods of time (Petterson et al, 2006). While the direct consequences of the hurricane were overwhelming, the indirect results were equally disparaging and “the breakdown in New Orleans’ social structure, loss of cultural heritage, and dramatically altered physical, economic, political, social and psychological character of the area are unprecedented in the United States” (Link 2010).

Hurricane Katrina struck the Gulf Coast states of Louisiana, Mississippi and Alabama on the morning of August 29th, 2005, four days after initial landfall on the southernmost part of the Florida peninsula (NOAA 2005). At its strongest, Katrina reached category 5 status, while moving across the Gulf of Mexico, but had been downgraded to a category 3 by the time it made its second landfall (NOAA 2005). The storms intensity has been compared to Hurricane Camille (the second strongest storm in history) in wind speed and central pressure, but Katrina spanned a greater distance in width, and therefore affected a larger area (NOAA 2005). Storm surge varied from 11 to 34 feet and federal disaster declarations were made over 90,000 miles of four states (Petterson et al. 2006).

Katrina raised issues in disaster management and relief/recovery that haven’t been discussed since Hurricane Andrew struck Florida in the early 1990s. Since Katrina, a flurry of reports and studies has been commissioned to analyze a variety of issues. Experts have looked into everything from why the existing infrastructure failed to the disaster preparedness of at-risk cities to the impact of the population and displacement factors in the aftermath. Much of the research gathered for this paper is the direct result of this action.

According to Heinz Luegenbiehl (2007) in reference to damage caused by Hurricane Katrina “most often, of course, in events of great magnitude no single cause is determinable, making such assessments fraught with uncertainty and the tendency to scapegoat.” The damage and the recovery will be complex. Multiple factors, as reported by the Independent Levee Investigation Team, include the hurricane itself, poor performance of the levees, lack of global organization in relation to the “design, construction, operation, maintenance and funding of the overall flood protection system” (Luegenbiehl 2007).

The damage inflicted on the residential sectors of Louisiana, Alabama and Mississippi was staggering. Areas that were most impacted were disproportionately low income, rental and elderly, as were the deaths (Petterson et al. 2006). The reaction of FEMA was to house displaced persons temporarily in hotels, funded by the national government, but in February of 2006 nearly a quarter of those people were still without permanent housing (Petterson et al. 2006). The results of an on-site analysis of the damage to 27 houses by van de Lindt et al., after Katrina revealed that much of the structural damage by wind was the result of building codes not being met in regards to roof sheathing, exterior siding and connection details (2007).

Louisiana Architecture

Architecture is important in New Orleans. The city has long been synonymous with picturesque streets lined with trees and wrought iron, an image that is very realistically in danger of being altered forever with the reconstruction of the city after Hurricane Katrina. The architecture “is a stage for the Crescent City’s everyday life and, no less important, a complex record of the human history of the city, region and nature” (Upton 2006). A city is defined by its relationships and the interactions that occur because of those connections, architecture may be thought of the same way (Upton 2006). In a comparative analysis of Creole architecture, Jay Edwards mentions that the record that is being remembered might be biased as a result of large and well-built houses maintaining priority over being preserved over smaller, more numerous structures. This selective preservation of structures can result in the impression of a "more elegant past than actually existed" (Edwards 2006).

The area was originally settled by the French, a connection that remains imperative to maintaining the true character of New Orleans and the surrounding cities (Petterson et al, 2006). Until recently, the concept that the French settlers had adapted traditional architecture to acclimate to the Louisiana heat and humidity, but more recent work has connected existing structures to ones in the Caribbean islands, with the idea that thought that regional accommodations were actually made by those who came to America from West Africa (Edwards 2006).

Reconstruction Process

Reconstruction typically pits two different ideals and sets of goals against each other: the desire to finish rebuilding quickly, for the sake of the displaced residents now, and the need to evaluate the problems that led to the mass destruction of infrastructure and right the problem, for the sake of the residents in the future (Olshansky et al, 2008). Arguments for which is more important can be made from both camps, but in most instances, a type of combination prevails- a frenzied evaluation that leads to a cautious rebuild.

The aforementioned categories represent a wide range of professions, skills and knowledge. Many different systems must be incorporated to successfully recover a decimated region, and it's easy to look at the historical data that clearly reveals that the systems in place aren't working individually. Each of the current programs addresses a component of the recovery/reconstruction process, but lack continuity and the flow of information necessary to ensure the programs work. One systemic approach that attempts to incorporate all aspects of the situation is referred to as disaster management or DM (Sagun et al, 2009). The authors of the article "A scenario-based study on information flow and collaboration patterns in disaster management" encourage the use of information and communication technologies to navigate through the standard three-stage disaster model (Sagun et al, 2009). These stages are specifically: preparedness, response and recovery. Architects/designers and construction managers play vital roles in both the pre and post disaster phases (Sagun et al, 2009).

Construction managers have always been involved in the post disaster or recovery phase, but the key to the disaster management theory is their involvement in the preparation. The model discussed in Sagun's work (2009) is the Intelligent Disaster Collaboration System which operates on three levels: local, regional and national, with the focus on three types of collaboration: tools for detection, decision-making, and resources for implementation. It is important to note that the construction industry can continue to refine their response and approach to recovery on their own, but regardless of how well the reconstruction of infrastructure goes, the success of the recovery will be based on the weakest system. Therefore, it is in everyone's interest to establish a method that allows for open communication and collaboration to help navigate all the channels of the recovery process.

New Orleans Recovery

The goal in disaster recovery is to at least replace all that has been lost and at best to take advantage of the opportunity to better some of the following concepts: disaster mitigation, urban design, existing infrastructure, political reform and economic and social equity (Olshansky et al, 2008). In the aftermath of Hurricane Katrina, planning organizations of all kinds emerged, each with a differing opinion on the next course of action (Barnett and Beckman 2006; Olshansky et al, 2006). One particular plan was presented to the city and state government by the firm Wallace Roberts and Todd, LLC after being commissioned by the Mayor of New Orleans (Barnett and Beckman 2006). Their entire plan was comprehensive, covering city framework, mass transit, and flood protection, but in this instance, their neighborhood component held the most relevance (Barnett and Beckman 2006). The proposed plan “recommended a neighborhood-based planning process to address the different rebuilding opportunities across the city over time to level the playing fields in terms of expertise and resources available to each neighborhood and to mesh with the citywide coordination plan” (Barnett and Beckman 2006). One of the most important things that this particular plan acknowledged was the fact that each of the affected neighborhoods was going to need to be addressed individually, with attention placed on their particular needs for recovery (Barnett and Beckman 2006). Regardless of the plans, put simply, “a recovery process can be measured by its quality (the degree to which it returns the area to a state equal to or better than before the disaster) and the speed with which this occurs (Olshansky et al, 2008).

The damage caused by Hurricane Katrina was unfortunately focused in areas of the city that were less influential and tended to be minority populated (Barnett and

Beckman 2006). This brought to light racial and social issues that had been previously ignored. One of the largest issues that residents had with the recovery process was the determination of which neighborhoods would receive the financial help of the government (Petterson et al, 2006). Many of the city's 35,000 historic properties reside within the most impoverished areas, such as the Lower Ninth Ward, where residents rented rather than owned and many properties did not have insurance (Lubell 2005; Petterson et al, 2006). According to Ed Blakely, who was formerly in the forefront of New Orleans' recovery, it became important to address the ramifications of the broken window theory, which is simply the theory that crime is more common in neighborhoods that are less well kept (Holbein 2009). Blakely states that "blight reduction is the leading edge in neighborhood restoration, and you don't have recovery without neighborhood restoration" (Holbein 2009). Journalist Sam Lubell (2005) reported the following six rebuilding principles that were goals of the reconstructionists in the months following Katrina:

- Create a single, comprehensive and compelling plan that offers leadership to everyone involved in restoring and rebuilding
- Improve infrastructure
- Promote economic growth
- Enhance public services
- Promote a healthy environment and healthy people
- Plan and design communities that advance livability

Of the six defined principles, the last two relate specifically to sustainability. Utilizing sustainable practices for the built environment not only benefits the natural environment, but also encourages health in the building occupants. Materiality is one of the easiest ways to reduce a negative environmental impact. The other aspect of sustainability that has been discussed but is not always employed is longevity. A structure that endures over a longer period of time may reduce the environmental impact more than a building that requires a complete renovation, whether it uses sustainable materials and building systems or not.

Much of the successful reconstruction efforts have been led by nongovernmental and other grass roots organizations, such as: Habitat for Humanity, Make It Right, Global Green USA, Rebuilding Together, and the Neighborhood Empowerment Network Association (Olshansky et. al, 2008). Each organization has tackled the issues in New Orleans in different but inventive ways.

Make it Right

The Make it Right Foundation is the brain-child of actor Brad Pitt (Kennedy 2011). After touring the Lower Ninth Ward in 2007 and noting the lack of recovery and organizational involvement, he founded the organization to build 150 green houses (Make It Right 2009). Pitt approached leading architects, who donated their services by designing the houses and the foundation subsidizes the construction costs (Kennedy 2011). Measures were taken to make the houses as disaster resistant (specially engineered walls, storm fabric for windows, raised elevations and metal roofs, among others) and sustainable (photovolatics, low flow plumbing fixtures, rainwater harvesting and pervious concrete) as possible (Home Features and Materials 2009). The architects incorporated vernacular architectural features including a shot-gun floor plan, deep front porches and pitched roofs (Kennedy 2011). As of May 2011, eighty of the houses had been completed (Kennedy 2011).

Global Green USA

Global Green USA focused much of their reconstruction efforts in the neighborhood of Holy Cross, which is adjacent to the south of the Lower Ninth Ward (Rebuilding New Orleans 2011). According to Finch et al, in their article "Disaster Disparities and Differential Recovery in New Orleans" (2010), Holy Cross was one of the sections with the highest intersection of flood depth and social vulnerability. Global Green USA teamed up with actor Brad Pitt to sponsor a design competition to include five sustainable houses, an apartment complex and a community center (Blas 2007). The competition generated almost 130 entries, with the final selection being made on August 20, 2006 in favor of Matt Berman and Andrew Kotchen from Workshop/apd (Holy Cross Project 2011). As of August 2011, the five houses had been built with two occupied, and the community center was set to be constructed in 2012 (Petersen 2011). The vision of Global Green is to create "an iconic sustainable village that will be a catalyst for years, if not decades to come" (Petersen 2011).

Neighborhood Empowerment Network Association

The Neighborhood Empowerment Network Association (NENA) is unique compared to the other organizations discussed here because it was formed after Katrina by Ms. Jones, a resident of the Lower Ninth Ward, to help other residents apply for disaster assistance and to guide them through the rebuilding process (Wallace 2008). The association is funded through donations and grants and does not provide construction services, though it has expanded to include a design studio with two architects (Wallace 2008). By 2008, the NENA had already assisted 1200 residents work through the recovery process (Wallace 2008).

Rebuilding Together

The mission of Rebuilding Together is to "improve the quality of life of low-income, elderly and physically disabled homeowners through home repair" (1000 Days Later 2008). All work is done by volunteers, and after Hurricane Katrina, the organization turned into a year-round effort (1000 Days Later 2008). As a result of their involvement with the elderly community, Rebuilding Together focuses on rehabilitating entire neighborhoods, so to ensure that no particular resident is left in an isolated area (1000 Days Later 2008). Rebuilding Together pledged to rebuild 1,000 homes in the Gulf Coast region, with the original goal of completion in 2011 (About Rebuild 1000 2008). As of March 2010, 718 of the houses had been built (Rebuild 1000 Statistics 2010).

Habitat for Humanity

Habitat for Humanity is widely known for their innovative approach to provide housing for families in need. In addition to the work they do every day in communities all over the country, they have a focused disaster response plan, wherein they offer "expertise in technical information; program design and implementation; and disaster response policies, protocols and procedures" (About Disaster Response 2011). They applied their mission "to develop innovative housing and shelter assistance models that generate sustainable interventions for people vulnerable to or affected by disasters or conflicts" to the city of New Orleans after Hurricane Katrina in the form of Musicians' Village in the neighborhood of Saint Claude (Habitat for Humanity 2011; Gordon, 2007).

In 2006 Habitat for Humanity teamed up with musicians Harry Connick, Jr., and Branford Marsalis to develop a small neighborhood comprise of seventy single-family houses, five duplexes, a performance center and park (Gordon 2007). The area was originally envisioned to help recover the music scene in New Orleans, fair housing laws have dictated applicants of all professions must be considered (Gordon 2007). The design team strove to embrace the neighborhood vernacular, building elevated homes with traditional gabled roofs and wood siding that adhered to the traditional shotgun lot dimensions (Verderber 2010).

Each of the above mentioned programs works independently on their recovery efforts. The main focus of some of the reconstruction organizations is sustainability, while others focus on speed, ease of construction or initial cost. The result is a variety of houses that span the spectrum of sustainability.

Analysis Tools

Several tools are required to analyze the exterior elements of a structure, as well as the factors that contribute to the decision to use each element or system. Geographic information systems allow for preliminary site information to be gathered, while detailed surveys and photographs document field information during studies. Sustainability matrices identify and assign points to building features and practices that are considered “green” while life cycle cost analysis computes total cost to erect and maintain a structure for a given life period. Quality modeling is a comparison method that incorporates all of the previous information mentioned, processes that information through a weighting system and allows all options to be compared using the factors that are identified as relevant for the project.

Geographic Information Systems

Geographic Information Systems (GIS) utilizes hardware, software and data to “collect and analyze geographically referenced information, which creates models that associate attribute data with specific aspects of physical spaces” (Geographic Information System GIS 2011). The heart of GIS is the science of mapping (Maantay and Ziegler 2006). According to Mark Monmonier, an authority on the subject of mapping, “maps are scale models of reality” (Maantay and Ziegler 2006). World maps can historically be traced back to 500 BC, although localized versions were used prior to that time for hunting and gathering (Maantay and Ziegler 2006). Maps were not only used to describe physicality of the land but also as a means to organize groups of similar people be it by religion, philosophy, beliefs or as a means to increase political control over a region (Maantay and Ziegler 2006).

As technology and science have advanced over time, the concept of mapping has as well. The invention of the Global Positioning System (GPS) bridged the two disciplines by demanding more and more precise technological measurements (Maantay and Ziegler 2006). According to Maantay and Ziegler (2006) GIS is “an integrated system of components: information about the real world that has been abstracted and simplified into a digital database of spatial and nonspatial features, which in conjunction with specialized software and computer hardware, and coupled with the expert judgment of the GIS user or analyst, produce solutions to spatial problems.” While there are many complex GIS programs in existence, other programs are designed for the general public and include tools to disseminate the spatial results (Curtis et al, 2006). This technology has a variety of applications including: gathering mortality information post-Katrina, monitoring urban sprawl and assessing the potential damage that may be caused by a major earthquake in Iran (Curtis et al, 2006; Durieux et al, 2008; Hashemi and Alesheikh 2011).

Building Code

The Florida Building Code: Hurricane Andrew

As previously mentioned, the Florida Building Code underwent a major overhaul in the aftermath of Hurricane Andrew. Andrew hit the Miami-Dade area of Florida (the southernmost tip) on August 24th 1992 causing an unprecedented amount of damage to Florida and later somewhat minimal damage to Louisiana (NOAA 2009). In addition to the costly damage that Andrew caused, it also revealed severe issues with inadequate construction methods and building inspections that was an ongoing problem in Florida (Stark 2002). Consequently, the state realized that something must be done to better protect the residents and infrastructure of Florida.

The inevitable changes were long in coming, however, and met with resistance from all industry parties involved (State Legislatures 2001). Some preliminary changes had been passed to address mobile homes in 1994 and hospitals in 1997, but prior to the adoption of the Statewide Unified Building Code in 2000; the state had operated with some 467 local building codes (Chastain et al. 2004; Stark 2002). Many of the “changes” were not in fact new, according to Jack Glenn of the Florida Home Builders Association, but rather stricter enforcements of elements previously added to the code, just not adhered to (Stark 2002). The elements with the most changes related to reducing flying debris, but increasing the requirements for fastening exterior elements (Stark 2002). Inspections were also adjusted, requiring more specificity on plan review and inspections because, as stated by planning manager in the Department of Community Affairs, Mo Madani, “You could write the strongest code in the country and if you don’t inspect properly, it wouldn’t matter” (Stark 2002).

One specific problem that occurred in Florida with Hurricane Andrew was the consistent failure of gable-end roofs (Bradford and Sen 2004). As mentioned in previous sections, hurricane winds can cause damage for roofing systems through suction and internal pressure (McDonald 2003). Gable-end roofs are configured in such a way that they terminate in a vertical plane at the end of a wall that is subject to inward pressure and outward suction by hurricane winds (Bradford and Sen 2004). The systems can lack the lateral bracing needed to counteract these forces, leading to structural collapse and exposure of the attic plenum (Bradford and Sen 2004). Updates to the building code in the years following Hurricane Andrew provided recommendations and methods to successfully utilize gable-end roofs (Bradford and Sen 2004).

The International Residential Code: Hurricane Katrina

Prior to Hurricane Katrina, Louisiana's approach to building codes was to provide a state standard, but allow local government to decide whether to enforce it or not (Chittum and Francis 2005). In the months following Katrina, the governor of Louisiana signed legislation for the adoption of the International Building Code, allowing application to be delayed a maximum of 90 days, if the parish was without building enforcement officials (Bergeron and Sawyer 2006). Reportedly, 57 parishes were without a code office when Hurricane Katrina struck (ENR 2007). Since that time, the updates provided by the International Construction Council have been adopted, as well as the addition of the International Residential Codes, with some amendments to increase high-wind protection (Department of Public Safety 2011).

Some of the backlash to the strengthened building codes has been because of the belief that it will increase insurance and reconstruction costs to the point that some residents will not be able to rebuild (Bergeron and Sawyer 2006). Another point is that the code mostly addresses wind issues, whereas most of the damage sustained in Louisiana was caused by flooding (Bergeron and Sawyer 2006). According to James Schwab with the American Planning Association, “the only way to survive that [flooding] is to raise the building off the ground and let the flood waters or storm surge pass underneath. Basically you’re on stilts,” (Chittum and Francis 2005). While the code may not address the flooding issue per se, it will help to instill confidence in investors who have been concerned with reinvesting in Louisiana, “Investors flee from blight; they think there is going to be more crime in the area and they feel there is less public expenditure. So you saturate it with code enforcement,” says Ed Blakely, head of the Office of Recovery and Development Administration, which was formed post-Katrina (Bergeron and Sawyer 2006; Holbein 2009).

Sustainable Metrics

The green building movement is gaining momentum, and with that a multitude of building rating systems have been developed, each different and with unique benefits. Reasons for selecting the different systems vary from cost to applicability but the most important factor remains that “environmental features need to be accessible in a consistent and coherent form, so they may be utilized within the context of all other competing factors (aesthetics, economics, performance, safety, utility) in building design” (Scheuer and Keoleian 2002).

Leadership in Energy and Environmental Design

LEED or Leadership in Energy and Environmental Design is the building metric developed by the United States Green Building Council in 2000 (USGBC 2011). The USGBC is a nongovernmental organization that is comprised of industry leaders from disciplines relating to the built environment (Scheuer and Keoleian 2002). Unique LEED rating systems are available for a variety of projects including:

- New Construction
- Existing Buildings: Operations and Maintenance
- Commercial Interiors
- Core and Shell
- Schools
- Retail
- Healthcare
- Homes
- Neighborhood Development

LEED for Homes was the rating system that corresponded with this study. The residences were single-family homes experiencing significant gut/rehabilitation, which met with the rating system requirements (Scope and Eligibility 2008). The system is divided into five environmental categories, followed by two additional categories:

- Sustainable Sites (SS)
- Water Efficiency (WE)
- Energy and Atmosphere (EA)
- Materials and Resources (MR)
- Indoor Environmental Quality (IEQ)
- Innovation and Design Process (ID)
- Regional Priority (RP)

The environmental categories are used universally, the innovation credits address specific measures taken per project that aren't covered in the previous categories, and the regional priority credits vary by zip code, depending on which issues were voted most important (LEED FAQ 2011). One of the benefits that LEED enjoys is its wide-spread acceptance (Owens and Sigmon 2010). The International Code Council has released the International Green Construction Code, which can be easily used and adapted by jurisdictions with the LEED rating system (Owens and Sigmon 2010).

Building ratings are based on a 100 base point system, with an additional ten points that may be earned (LEED FAQ 2011). The ratings are as follows:

- Certified (40-49)
- Silver (50-59)
- Gold (60-79)
- Platinum (80 +)

The cost to certify a project using LEED varies by situation, but according to the USGBC, a standard baseline is $2000 (LEED FAQ 2011).

Florida Green Building Coalition

The Florida Green Building Coalition was founded in 2000 and is "dedicated to helping builders, developers, contractors, local governments, and consumers achieve a healthier and more environmentally sustainable future" (FGBC 2011). The FGBC checklist is comprised of eight categories:

- Energy
- Water
- Lot Choice
- Site
- Health
- Materials
- Disaster Mitigation
- General

According to the Standards and Policies document (2011) each category has both minimum and maximum points allowed, and the system has four levels of certification:

- Bronze (0-30)
- Silver (31-60)
- Gold (61-90)
- Platinum (91 +)

There are two specific benefits to using the Florida Green Building Coalition rather than LEED and Green Globes. First, the program was designed around the hot, humid climate of Florida, thereby setting the performance standards at a level that is attainable in the southern region (FGBC 2011). Also, the FGBC contains a section on disaster mitigation, specifically focusing on the additional codes for hurricane-wind zones (FGBC 2011).

Green Globes

Green Globes was originally released as a web-based assessment tool for buildings in Canada in 2002 (Green Globes Emerges 2005). Once it made the move to the United States, it was overseen by the Green Building Initiative, which is an "accredited standards developer under the American National Standard Institute" (What is Green Globes 2011). The rating system works for projects of all sizes and incorporates seven different categories for analysis (Why Green Globes is Better 2011):

- Project Management Policies and Practices
- Site
- Energy
- Water
- Resources: Systems and materials selection
- Emissions, Effluents and Other Impacts
- Indoor Environment

The categories for Green Globes are broader the LEED and incorporates issues such as optimization of space, acoustical comforted as well as integrated design and life cycle cost analysis (which have also been recently incorporated into LEED) (Green Globes Emerges 2005). Costs for Green Globes range from $500 for access to the assessment to between $3.000 to $5,000 for the third-party verification (Green Globes Emerges 2005; GG FAQ 2011).

Quality Modeling

Value Engineering (or Management) was developed by Lawrence Miles and is useful in "addressing challenges such as budget constraints and project complexity in the construction industry” (Lin and Shen 2007). One component of this field of study is quality modeling. Quality models are best used to “assist in the defining, measuring and managing of owner quality expectations” (Kirk 1994). Once owner expectations are clarified, the model may be used as a decision-making tool (Kirk 1994). The process for generating a quality model consists of the key decision-making personnel working together to define which characteristics are driving forces in the project (Kirk 1994). Examples of these factors include:

- First cost
- Aesthetics
- Life Cycle Cost
- Labor Intensity
- Sustainability
- Durability

The exact definition of each factor is determined by the owner and provided in narrative form, as is the relative importance of each characteristic in relation to the others (Kirk 1994). When this tool is developed early in design development, it is most useful as the decision-making tool, but it can also be utilized later in the process to manage quality (Kirk 1994).

CHAPTER 3
METHODOLOGY

Overview

The main objective for this research is to identify the materials being utilized in the reconstruction of New Orleans after Hurricane Katrina. The research was limited to the exterior envelope, or systems that could be observed and identified from the street. Visual images were utilized extensively in this study, not only as a means to gather information, but also to verify written data and document observations.

Once building system options were identified, supplemental information was used to attempt to explain why those particular materials were chosen. Rather than to definitively declare the best system, quality modeling was applied to each of the materials, using nine different factors, to allow the results to be sorted based on a variety of characteristics. The options in roof, exterior wall system, and foundation type and material which attained the highest value were then combined to form an “ideal” option. This ideal was compared to the most frequently occurring combination in each neighborhood.

Process

Two methods were utilized to gather the necessary information for this research: investigation of New Orleans neighborhoods and development and utilization of analytical tools. Work was done simultaneously in both areas, gathering information about and conducting the field study while developing the tools later used to analyze the field information. As seen in Figure 3-1, the paths often converged. Ultimately, both branches of research led to an evaluation matrix, which organized the data for further investigation into the sustainability and life cycle cost of each option. This was then

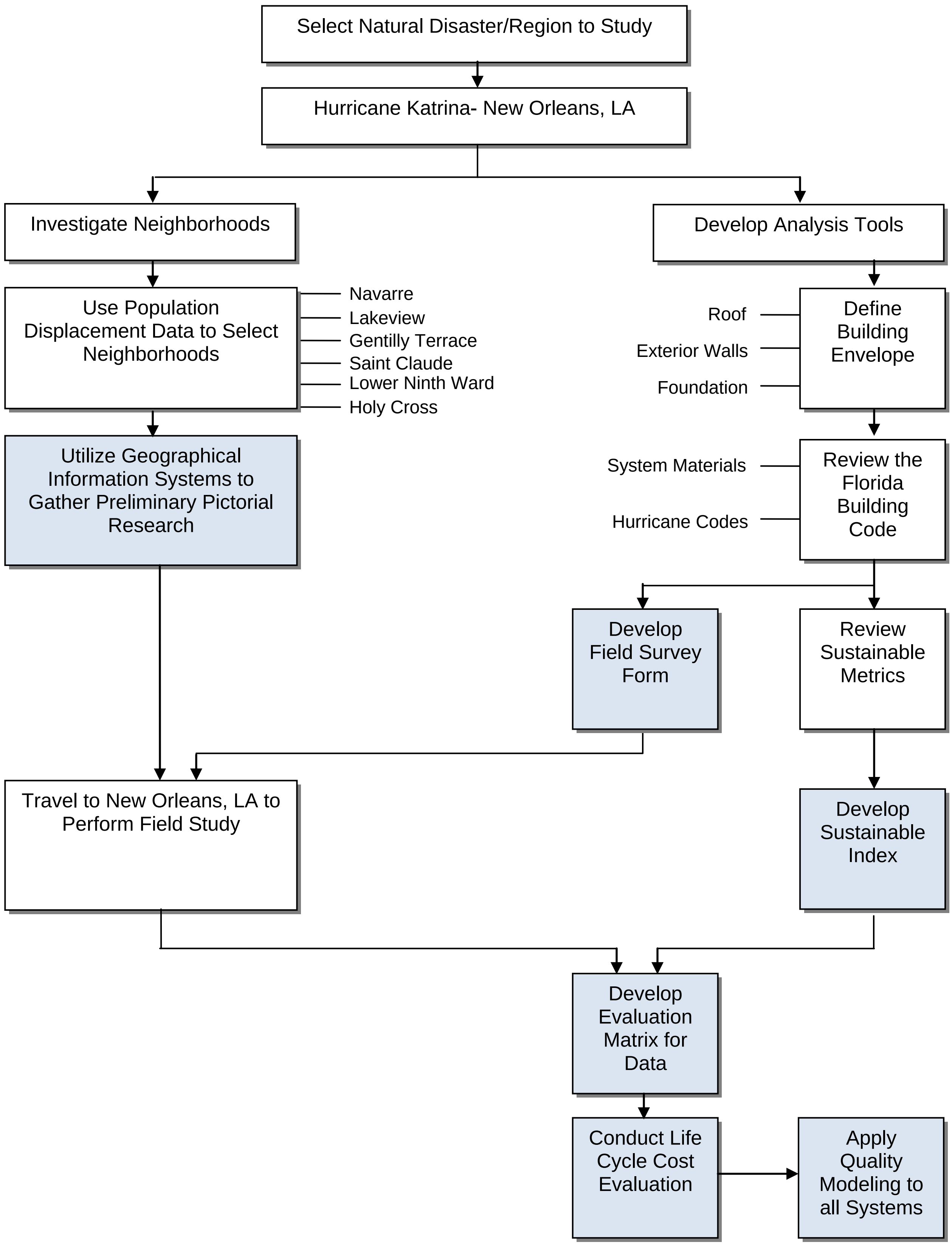


Figure 3-1. Methodology flow chart

inputted into the quality model for comparison. In the figure below, steps in the methodology that produced a visual entity are shaded.

Investigation of the Neighborhoods

The first step in executing the study was to research the parishes in New Orleans, to determine which areas would prove most appropriate to study. In the case of New Orleans, as with most large cities, the metropolitan area is comprised of smaller neighborhoods that vary in wealth, race, age, profession and a variety of other social characteristics. It was determined for this study that the most comprehensive results would be achieved by studying areas of New Orleans that had all had the same physical impacts of Hurricane Katrina, but experienced a variety of social characteristics. In the article “Disaster Disparities and Differential Recovery in New Orleans,” which was cited in the review of the literature under “Effects on Population and the Built Environment,” investigators Finch, Emrich and Cutter (2010) provide synthesized data identifying the level to which each neighborhood experienced flooding in comparison with their social vulnerability. Social vulnerability is defined as “the socioeconomic characteristics that influence a community’s ability to prepare, respond, cope and recover from a hazard event” (Finch et. al, 2010). This information provided the ground work for selecting neighborhoods for this study. Finch et. al, identified flood depth as “none”, “low”, “medium” and “high”, and social vulnerability as “low”, “medium” and “high” (2010). For this study only areas that experienced “high” flooding (greater than four feet) were selected, while neighborhoods in all three socially vulnerable categories were chosen (see Figure 3-2).

Neighborhood selection

Different neighborhoods in New Orleans suffered from different levels of flooding. In the interest of continuity throughout the field study and in an effort to only have one changing variable (social vulnerability) only neighborhoods with a "high" level of flooding, which was considered four feet of standing water or deeper, were selected (Finch et. al, 2010). These were purposefully chosen because areas of high flooding were more likely to have had similar damage and the need for major renovations for most houses. The range of social vulnerability would also allow for remarks to be made on how the different neighborhoods responded to the recovery process. The literature had revealed that social inequity became an issue post-Katrina and this field study allowed for those issues to be observed. The following six neighborhoods were selected for further analysis:

- Navarre (high flooding, low vulnerability)
- Lakeview (high flooding, medium vulnerability)
- Gentilly Terrace (high flooding, low vulnerability)
- Saint Claude (high flooding, medium vulnerability)
- Lower Ninth Ward (high flooding, medium vulnerability)
- Holy Cross (high flooding, high vulnerability)

These neighborhoods spanned the width of New Orleans Parish (see Figure 3-2) and represented four districts: Lakeview, Gentilly, Bywater and Lower Ninth Ward (GNOCDC, 2003). The neighborhoods chosen for analysis may be seen in Figure 3-2. Each area's social vulnerability is identified by color:

- Low vulnerability: teal
- Medium vulnerability: blue
- High vulnerability: red

Additionally, the neighborhoods are numbered one to six, occurring in the same order as mentioned in the list above.

Figure 3-2. Map of New Orleans Parish with selected neighborhoods. (©2011 Google, ©2011Europa Technologies)

As seen in the figure above (Figure 3-2) the neighborhoods that were chosen spanned the width and length of the New Orleans Parish. This variance in location worked with the differing social vulnerabilities to provide the most holistic picture of the Louisiana community's recovery.

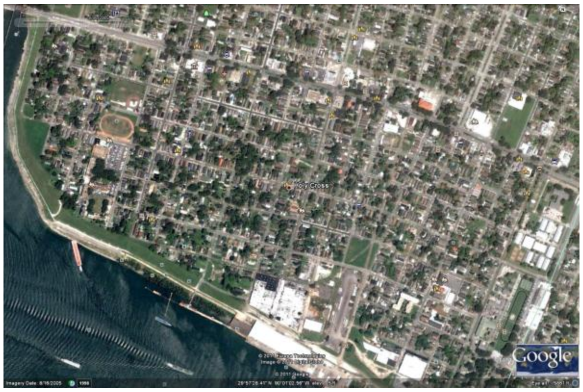
For the purposes of the field study, the Greater New Orleans Community Data Center (GNOCDC) was utilized to define the cardinal boundaries of each neighborhood, as seen in Table 3-1. These boundaries were then used during the field study to define the scope of each area. It was important to clearly define the zones analyzed to allow for future replication of the study.

Table 3-1. Neighborhood street boundaries for field study

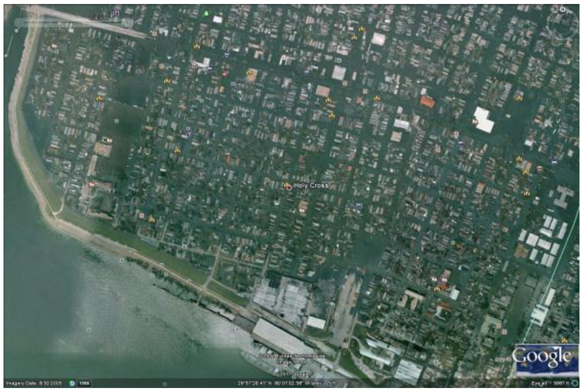
Neighborhood	Direction	Street
Navarre	North	Florida Boulevard
	South	City Park Avenue
	East	Orleans Avenue
	West	West End Boulevard
Lakeview	North	Robert E Lee Boulevard
	South	Florida Boulevard
	East	Orleans Boulevard
	West	Pontchartrain Boulevard
Gentilly Terrace	North	Filmore Avenue
	South	I-610
	East	Peoples Avenue
	West	Elysian Fields Avenue
Saint Claude	North	North Galvez Street
	South	Burgundy
	East	Lessops Street
	West	Franklin Avenue
Lower Ninth Ward	North	Florida Avenue
	South	Saint Claude Avenue
	East	Dubreuil Street
	West	The Canal
Holy Cross	North	Saint Claude Avenue
	South	The Mississippi River
	East	Delery Street
	West	Sister Street

Geographical information systems research

Once the neighborhoods had been selected via the displacement study, the information was verified using geographical information systems technology, specifically Google Earth. Each area was reviewed separately, using the historical data option to look at the same image on four different dates, over the course of six years (See Figure 3-3). December 30, 2004 was the first date chosen for five of the neighborhoods, to provide context for the area prior to Hurricane Katrina. The exception to this is the review of Holy Cross, which begins on August 16, 2005, due to lack of available information. The second image was taken on August 30, 2005; one day after Hurricane Katrina struck New Orleans. Water is clearly visible in all images, thereby verifying the finding of the displacement study by Finch et. al, (2010). The third image was taken on June 12, 2006, almost ten months after the hurricane made landfall. The disrepair is visible even from the aerial perspective, as are the FEMA trailers and blue tarped roofs. The final image was taken on March 22, 2010, the most recent information available, and shows each of the neighborhoods in their differing states of repair.

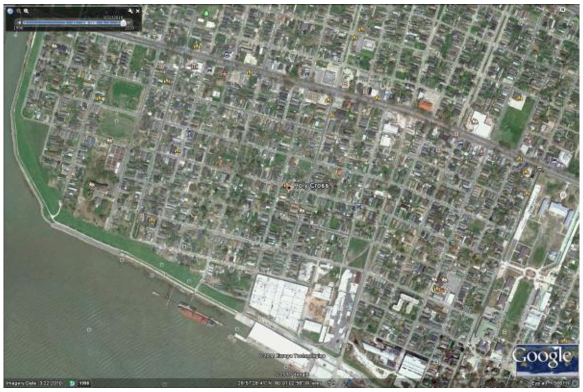


A.



B.

C.



D.

Figure 3-3. Series of images of the New Orleans neighborhood Holy Cross collected from Google Earth. A) taken on August 16, 2005; thirteen days prior to Hurricane Katrina B). taken on August 30, 2005; one day after Hurricane Katrina C) taken on June 12, 2006; nine months after Hurricane Katrina and D) taken on March 22, 2010; four and a half years after Hurricane Katrina. (©2011 Google, ©2011Europa Technologies, ©2011 Digital Globe, Images: US Geological Survey, NOAA)

For the images collected for the subsequent five neighborhoods, see Appendix D.

New Orleans field study

As evidenced in the methodology flow chart above (Figure 3-1), the Field Study Form (see Appendix C) was developed prior to traveling to New Orleans. The actual study was completed over the course of two days, surveying six neighborhoods, twenty houses apiece for a total of 120 houses. In an effort to select houses randomly, it was determined prior to the start of the surveying that two houses per street would be reviewed. The surveyors would move from one parallel street to the next, reviewing the third house on the right as well as the residence directly opposite. In some instances, the neighborhoods were not comprised of at least ten parallel streets to survey. In that case, streets were duplicated, though always a different block was reviewed. All survey information was gathered from the street, and every effort was made not to encroach on the privacy of the individual home owners. In the instance that surveying a particular house would have invaded personal privacy, the next residence, in factors of three was chosen (i.e. house three, six, nine). Along these same lines, only street names, not house numbers, were documented.

Information was documented through the survey form and photographically, and included:

- Neighborhood
- Street Name
- House Type
- Roof Type
- Roof Material
- Exterior Wall Material
- Foundation Type
- Foundation Material
- Hurricane Code Compliance
- Sustainable Measures

Weather and neighborhood activity restricted the ability to take pictures of every residence surveyed, but photographs were obtained of each type of house, system material and neighborhood.

Develop Analysis Tools

Early in the research for this study, it became clear that several tools were needed to compile, organize and connect the information that came from multiple sources. Each of the matrices builds upon the previous ones, provides a holistic view of the current material trends in housing reconstruction.

Define building envelope

The first step was to define the scope of study in relation to the built environment. As mentioned in the review of the literature, many problems relating to hurricane damage are the direct result of issues with the exterior envelope. The "envelope" of the building consists of "all building components that separate the building's interior from the exterior environment" (Mehta et. al, 2008). For the scope of this study the exterior envelope includes:

- Roof Type
- Roof Material
- Exterior Walls
- Foundation Type
- Foundation Material

Only the outermost layer of the exterior envelope was considered, thereby excluding the different structural elements that are necessary to ensure the structural integrity of a house. The general assumption was made that all systems were built according to manufacturer's specifications as well as to meet any applicable building codes.

Review the Florida Building Code

As mentioned in the review of the literature, the Florida Building Code is considered the most stringent code relating to hurricane provisions. Prior to Hurricane Katrina, Louisiana did not enforce a state building code, but rather allowed enforcement to occur at the local level. These two factors led to the decision to use the Florida Building Code as the guideline for this study. Prior to dissecting the building code, the impression of this author was that certain systems would be more "hurricane proof" than others. Review of the building code revealed that the standard for any material that was naturally less conducive for hurricane environments was written to include all of the additional provisions to make the material strong enough to endure during storms, rather than simply disqualifying it. Virtually every material system can be used in hurricane wind zones; some just require more advanced measures to ensure their stability and homeowner's safety.

The Florida Building Code was used as a reference to determine which materials may be used for the roof, exterior walls and foundations of a house (see Table 3-2) as well to identify exterior features that are necessary to comply with hurricane code provisions:

- Vents
- Gutters
- Fence
- Open porch
- Screened porch with exterior wall support
- Roof overhang
- Metal flashing
- Grills of masonry
- Closed eaves
- Shutters

In addition to being utilized for the field study form, the analysis of the building code was critical in later determining product selection for the Life Cycle Cost, as well as the means to accessing the difficulty of hurricane codes with a particular material or system. The analysis of applicable building codes for this study can be found in Appendix A.

Table 3-2. Exterior elements from Florida Building Code: roofs

Envelope Element	System	Material
Roof	Shingles	Asphalt
		Slate
		Wood
	Tile	Clay Shingles
		Spanish Barrel
	Metal	Corrugated
		Sheet
	Other	Built-Up
		Green
		Sprayed Polyurethane

Table 3-3. Exterior elements from Florida Building Code: exterior walls

Envelope Element	System	Material
Exterior Walls	Masonry	Brick
		Pre-Cast Concrete
		CMU
		Stone
	Metal	Steel Siding
		Aluminum Siding
		Shingles
		Copper
	Wood	Shingles/Shakes
		Plywood
		Vertical Siding
		Horizontal Siding
	Other	Glass
		Stucco
		Vinyl Siding
		Fiber Board

Table 3-4. Exterior elements from Florida Building Code: foundations

Envelope Element	System	Material
Foundation		Cast-In-Place
		CMU
		Pressure-Treated Wood
		Brick
		Stone
		Steel

Develop field study form

The field study in New Orleans required documentation, which eventually took the form of a field survey. Once the building code had been reviewed and appropriate system options identified, the elements from Table 3-2 were organized into a format that allowed for quick notation. In addition to the material systems and the hurricane provisions from the previously mentioned section, other categories of information that were identified as important for analysis included roof type, foundation type (see Table 3-3) and any sustainable measures that were utilized. The full field study form may be found in Appendix C.

Table 3-5. Additional envelope elements

Envelope Element	System
Roof Type	Flat
	Shed
	Gable
	Hip
	Gambrel
Foundation Type	Piers/Stilts
	Slab-on-Grade
	Crawl Space
	Basement

Review sustainable metrics and develop sustainable index

A review was performed on three different sustainability metrics: LEED, Green Globes and the Florida Green Building Coalition. While the Florida Green Building Coalition is not applicable in all instances (and is not used at all) in Louisiana, it is the only metric that includes a section on disaster mitigation. Each system was reviewed individually for credits that were applicable for one or more of the envelope systems, materials or hurricane provisions. LEED produced seven credits from the categories of sustainable sites, materials and resources and energy and atmosphere, Green Globes had ten from project management, site, energy, resources and indoor environmental quality and Florida Green Building Coalition provided twelve in energy, site, health, materials and disaster mitigation. Each credit that was noted was further reviewed using the appropriate user guide and then summarized in the Sustainable Summary (see Appendix B). The credits were then input into a new sustainable index that allowed comparison between the credit and the elements of the building envelope (i.e. roof type, roof materials, exterior walls, foundation types, foundation materials, and hurricane provisions). The number of credits that each envelope element qualified for were then calculated, both per original sustainable metric (LEED, Green Globes, FGBC) and then as a total for all three. The Sustainable Index may be found in Appendix G.

Trend Analysis evaluation matrix

Once the field study of the six neighborhoods in New Orleans was completed, a matrix was developed to organize all of the gathered information and showcase building trends. It incorporated the following categories:

- Neighborhood
- Order of house evaluations
- Street location
- House Type
- Roof Type
- Roof Material
- Exterior Wall Material
- Foundation Type
- Foundation Material
- Hurricane Provisions

- Sustainable Measures

The matrix was developed to allow for more than one material or feature to be selected, in the instance that multiple were used for one house. Six different charts were formed, one for each of the neighborhoods (see Appendix F).

Life Cycle Cost analysis

Once the data was collected from the New Orleans field study, it was synthesized and used as the starting point for conducting life cycle cost analysis. This analysis was broken into three categories: roof materials, exterior wall materials and foundation type and materials. Each of the materials included was identified on at least one house in New Orleans. The information that impacted life cycle cost included:

- Initial cost
- Annual maintenance
- Repairs
- Replacement

Life cycle cost evaluation was used to calculate the cost of the material for a building with a life expectancy of 50 years. All initial cost information was collected from 2009 RSMeans Construction Cost Data, as were maintenance and repair costs, unless otherwise noted, and all costs were calculated at a discounted rate over time.

To perform life cycle cost analysis, some assumptions were necessary. The LCC requires amounts of the material needed, so a general building was defined. A typical shotgun house is approximately 1000 square feet, with dimensions of forty feet by twenty-five feet. The wall height was nine feet, with a gable roof with a pitch of five to twelve. For pier foundations, twenty-four five foot piers were used, for a crawl space, a wall with a height of four feet on grade, and for a basement, eight feet on grade. For exterior walls, not openings were subtracted, rather that material was considered the extra waste needed. For other systems, ten percent waste was factored in.

Quality modeling

The final step in the methodology was to incorporate all of the information gathered into quality models to quantify the characteristics that influenced material and system selection.

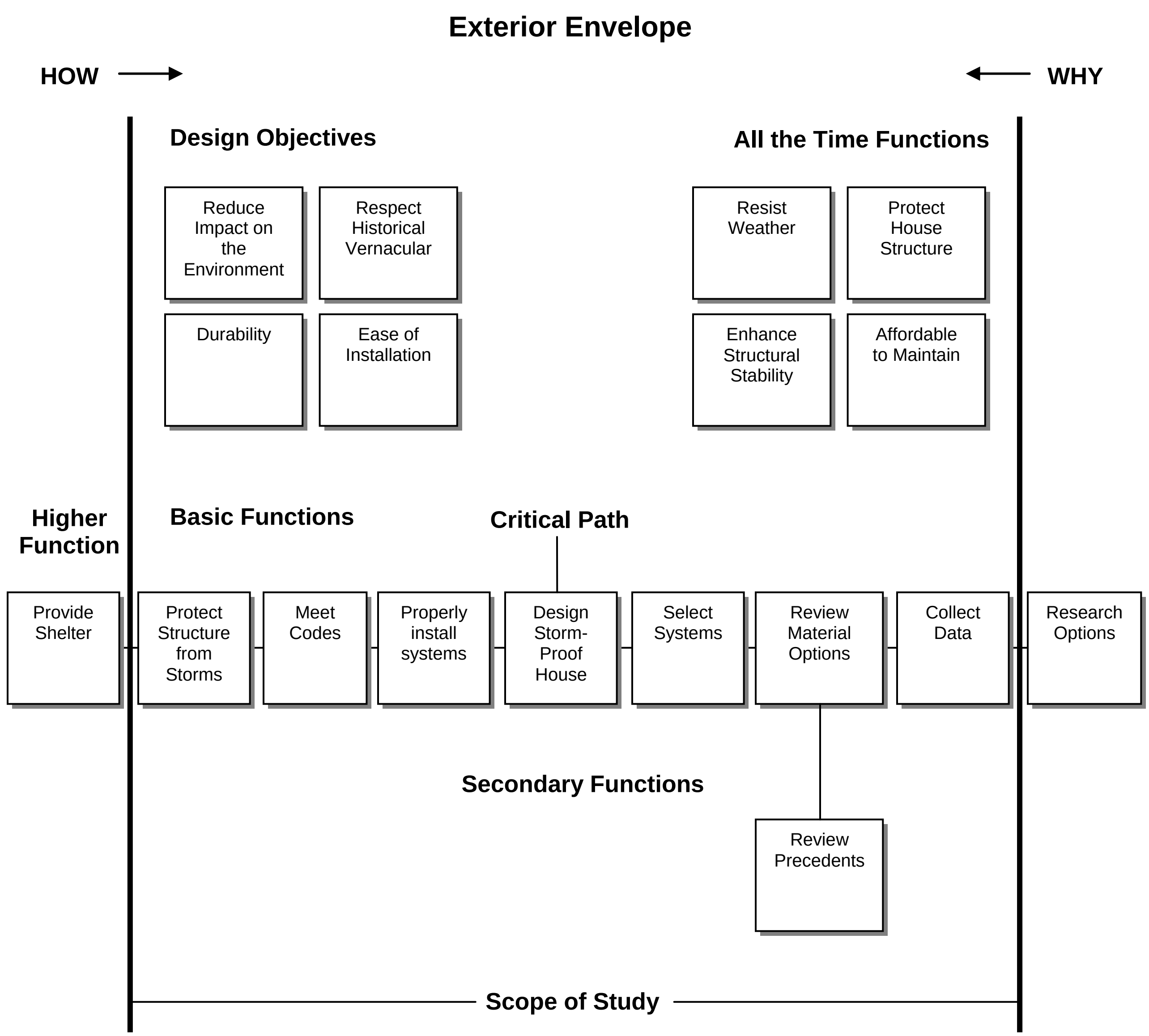


Figure 3-4. FAST diagram for the exterior envelope

Once the life cycle costing was complete, a FAST diagram was designed to understand the different functions of the exterior envelope.

According to the FAST diagram, the main function of the exterior envelope is to provide shelter (on the far left). This is accomplished by the successful completion of each of the basic functions along the critical path to the right. These functions were determined by asking "how" the function to the left would be accomplished and by

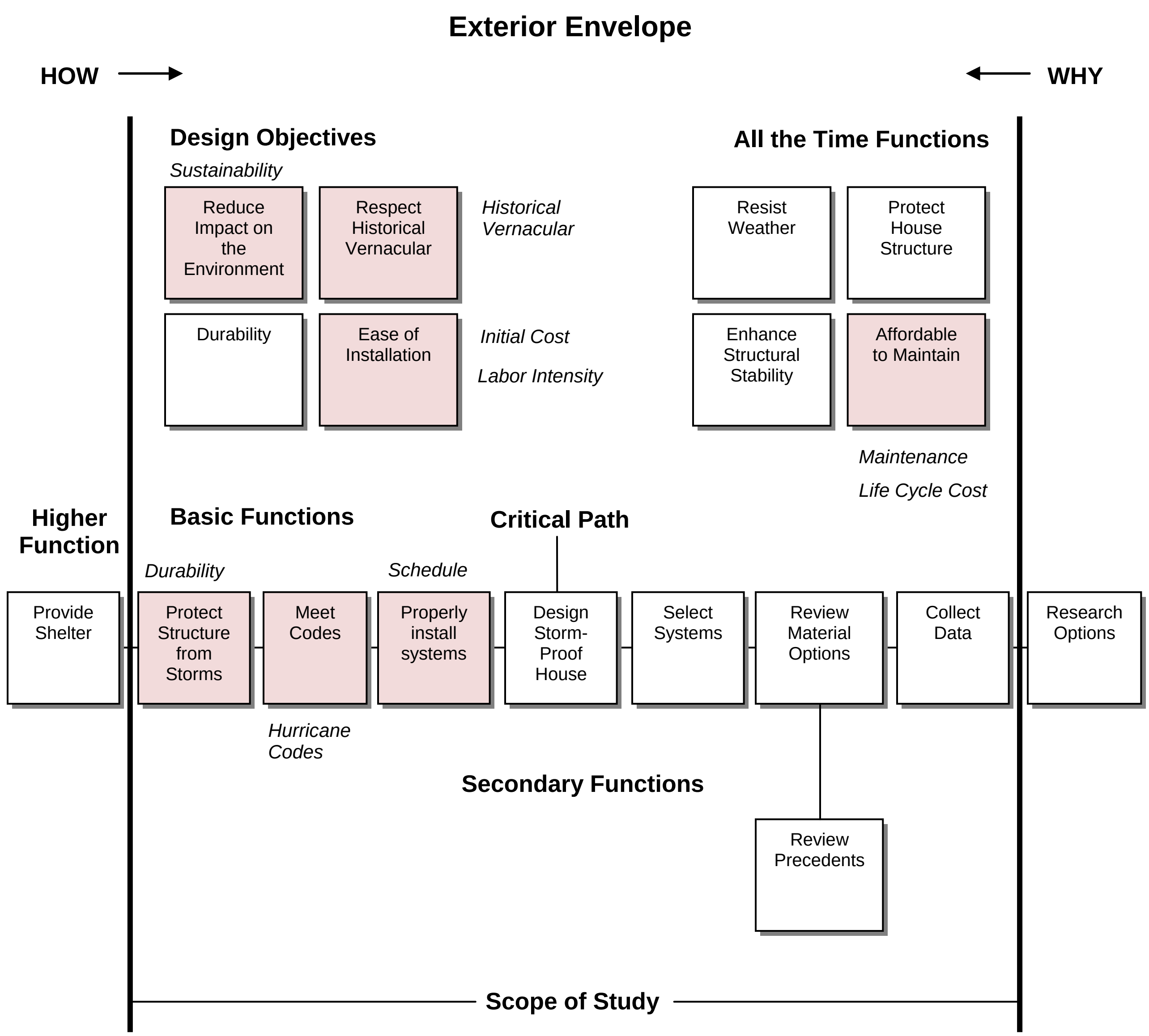


Figure 3-5. Characteristics for quality modeling

asking “why” the function on the right was completed. The design objectives and all the time functions act as guides in the decision-making process. As seen in Figure 3-5, the characteristics for the quality model (shaded boxes) were chosen directly from the FAST diagram, nine in total:

- Sustainability - decided from the score on the Sustainable Index
- Durability - the life expectancy of the material or system, compiled from various sources; determined for LCC
- Hurricane Codes - utilized the building code analysis to determine how easily a material could be incorporated and still meet the necessary codes
- Initial Cost – determined using RSMeans; determined for LCC
- Labor Intensity – what percentage of total initial cost is solely labor; an important factor when available labor is limited due to population displacement
- Historical Vernacular- how well each system blended with historic architecture
- Maintenance- total maintenance cost; determined for LCC
- Life Cycle Cost- how much the material will cost over the life of the building
- Schedule- how many days is takes to install the system; this is critical when rebuilding homes for displaced persons

Each of these characteristics represents one facet of the disaster relief process that is critical to the success of the reconstruction of New Orleans. Based on the conditions of New Orleans, the historical importance of architecture and the social and economic vulnerability of many of the individuals required to rebuild a weighted value was assigned to each factor, on a scale of one to five and incorporated into a RADAR diagram for ease of understanding. Next, a five-point Likert scale was determined for each characteristic from the range of values present in the system options identified in the field study. Finally, the Likert value for each characteristic was multiplied by the importance weight to determine an overall quantitative total for each exterior envelope element.

Comparison: quality model and neighborhood field study

Once quality modeling was complete, the mode (or most frequently occurring) material in each category for each neighborhood was calculated. A total cost for the three systems was determined using the life cycle cost for each material option. The most frequently occurring material selections for each neighborhood was then compared to ideal model derived from the quality model results, using both points, total life cycle cost and the sustainable index.

CHAPTER 4
RESULTS

Overview

The following chapter is devoted to the results of the various studies performed using the analysis tools outlined in the methodology. The process used was to synthesize the data collected in the New Orleans Field Study, compare the results to the newly-generated sustainable index, then perform life cycle cost calculations and quality modeling analysis on the information. Finally, the information that was generated from the quality model was compared to the original preferences from each neighborhood.

New Orleans Field Study

The information gathered in the New Orleans field study was organized into three overall categories for analysis:

- Roof Type and Material
- Exterior Wall Material
- Foundation Type and Material

During the field study, it became apparent that several houses employed more than one option. For instance, some houses utilized both gable and shed roofs, or stucco and brick for the exterior wall material. All of these options were documented in the study, so the numbers in all cases may add up to more than 100% or twenty houses. The full list of every house analyzed, with all of the individual house features and materials documented may be found in Appendix F, Neighborhood Survey Results.

Navarre

Navarre was the first neighborhood looked at during the field study. It was classified as high flooding, low vulnerability, and with the exception of a few residences under construction, looked to have been completely repaired. A variety of house types were present, including craftsman bungalow, colonial and Spanish-style (see Figure 4-1).

A

B

Figure 4-1. Two houses in the Navarre neighborhood (photographs by author)

Roof

Four of the five roofs types were found in Navarre: flat, shed, gable and hip. Additionally, the roof materials asphalt shingles, slate, clay tiles, and Spanish barrel tiles (also documented as Mission tiles) were noted. The combinations of both the roof type and material may be seen below in Figure 4-2.

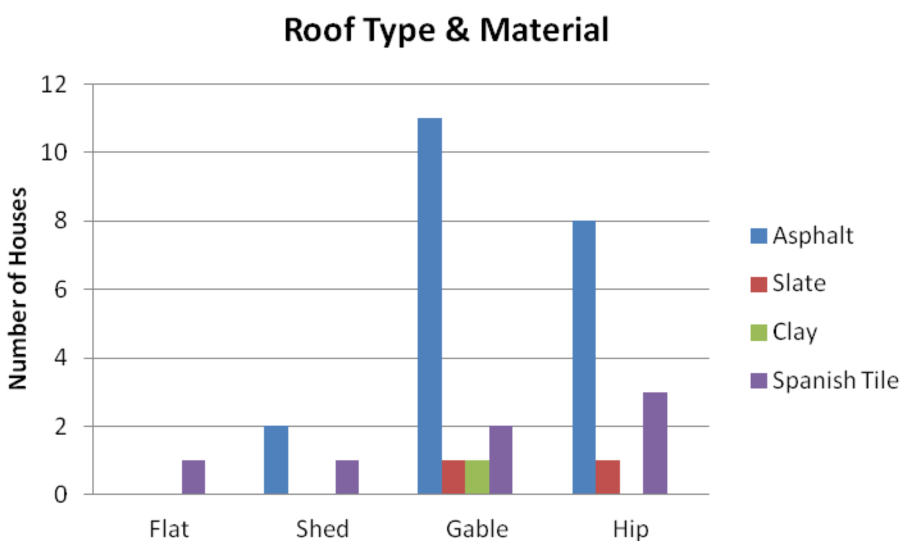


Figure 4-2. Navarre roof type and material results

Eleven houses had a gable roof with asphalt shingles, making the combination the most popular option, followed closely by hip roofs with asphalt shingles, which occurred eight times. In total, sixteen houses used asphalt shingles, while five used Spanish barrel tiles, the second most popular.

Walls

Navarre had the most variety when it came to exterior wall materials. Eight different options were documented, ranging from horizontal wood to wood shakes to pre-cast concrete panels (See Figure 4-3). Thirty-eight percent of the houses used horizontal wood siding as the main exterior wall material. Stucco was also a popular option, with nineteen percent, while twelve percent utilized cement fiber board.

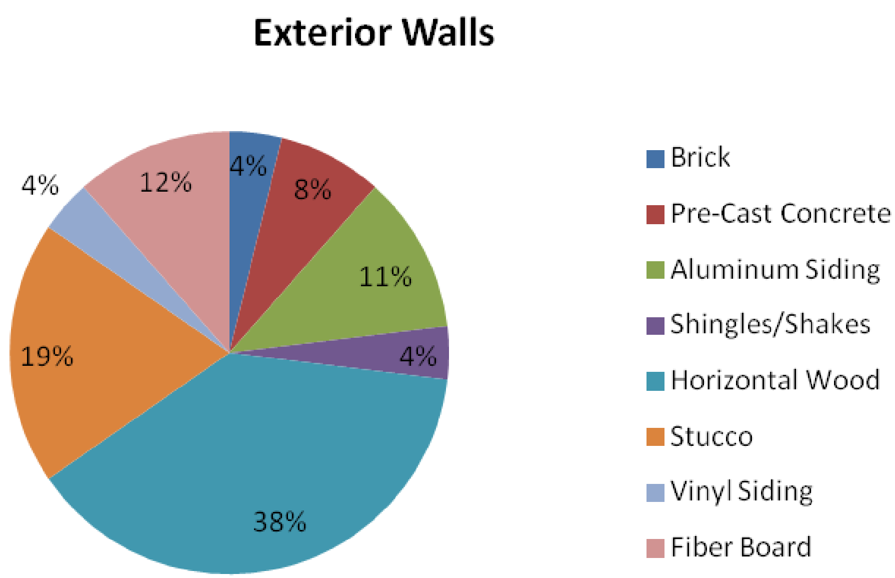


Figure 4-3. Navarre exterior wall material results

Foundation

The final exterior envelope element investigated was foundation type and material. Navarre was the only neighborhood to incorporate basements into some of the houses surveyed. The most frequent foundation type used was slab-on-grade. The second most popular was a crawl space enclosed in brick (see Figure 4-4).

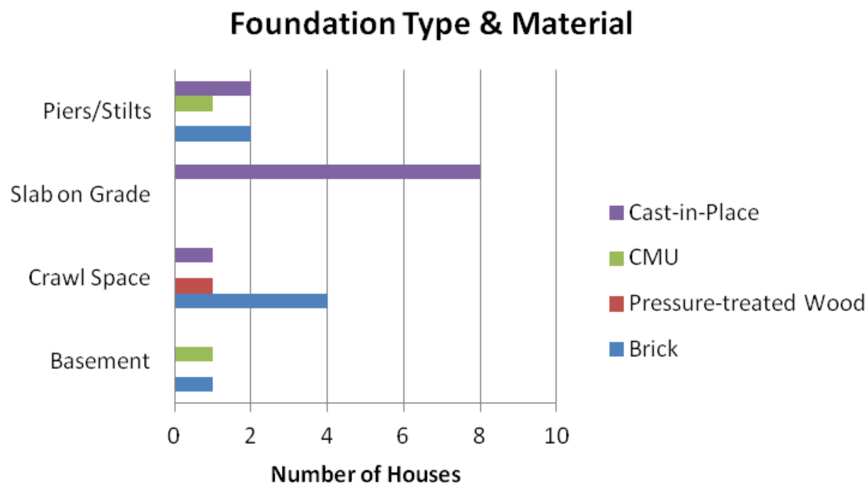


Figure 4-4. Navarre foundation type and material results

Lakeview

Lakeview was the second neighborhood investigated and was classified as high flood, medium vulnerability. Much of the Lakeview area was under construction when the field study occurred. A variety of house types were noted in the neighborhood, including bungalow and plantation, which are the historical vernacular for Louisiana, as well as modern, farmhouse and mission, which are not as prevalent (see Figure 4-5).

A B

Figure 4-5. Two houses in the Lakeview neighborhood (photographs by author)

Roof

The Lakeview neighborhood results revealed three roof types: shed, gable and hip, with the materials of asphalt shingles, Spanish barrel tiles and corrugated metal (see Figure 4-6). Seventeen houses used only asphalt shingles; one house combined both asphalt shingles with Spanish barrel tile along the seams, and two roofs utilized corrugated metal roofs. The most popular combinations were gable and hip roofs with asphalt shingles.

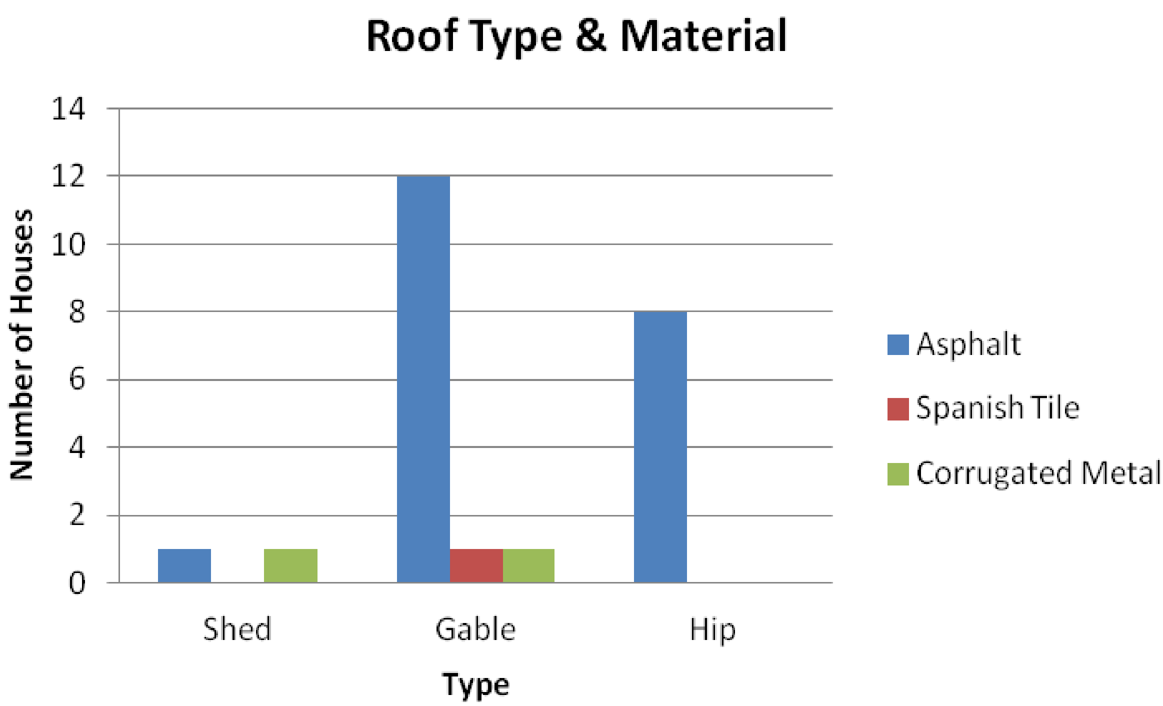


Figure 4-6. Lakeview roof type and material results

Walls

Horizontal wood siding was the most prevalent exterior material chosen in Lakeview with a percentage of thirty-three, followed closely by brick at twenty-nine percent (see Figure 4-7). Together, these two materials were on seventeen of the twenty houses. Other materials that were noted included stone, aluminum siding, stucco and cement fiber board. Stone and aluminum siding were the least frequently occurring materials in Lakeview, each exterior wall material occurred on only one house. A few houses incorporated more than one material, but only one utilized three: brick, horizontal wood siding and stucco.

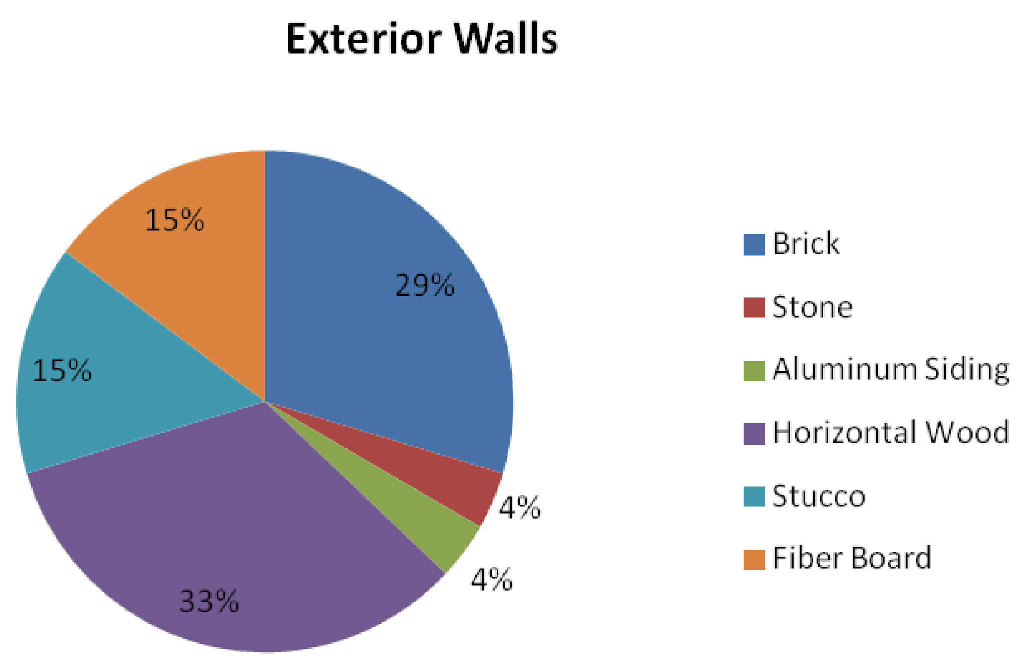


Figure 4-7. Lakeview exterior wall material results

Foundation

Basements were the only foundation type not found in the survey of the Lakeview neighborhood. Rather, foundations with an enclosed crawl space were the most frequent, with cast-in-place occurring slightly more frequently than brick. Two houses also used CMU for crawl spaces. Four houses still employed slab-on-grade as opposed to elevating the residences.

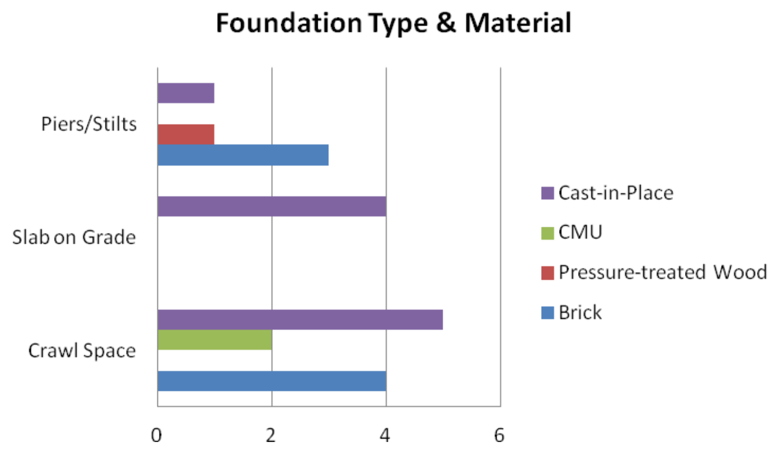


Figure 4-8. Lakeview foundation type and material results

Gentilly Terrace

The third neighborhood in the New Orleans field study was Gentilly Terrace. This area was categorized as high flood, low vulnerability. A few residences were in the middle of reconstruction, but for the most part the neighborhood had been recovered from the flooding damage. This was one of the only neighborhoods surveyed that had begun to repair the city infrastructure, or roads, most were still cracked and difficult to navigate. Half of the study subjects were cottages, making this the most popular house type in this neighborhood by far. A variety of other styles were employed by some of the larger houses including farmhouses and Greek revival.


A


B

Figure 4-9. Houses from the Gentilly Terrace neighborhood (photographs by author)

Roof

Gentilly Terrace was found to have houses utilizing four of the five roof types; shed, gable, hip and gambrel, although only three roof materials were documented: asphalt shingles, slate and Spanish barrel tile. Hip roofs were the most popular with eleven total, while gable roofs were close behind with nine (see Figure 4-10). Asphalt was the main material used on all but one of the houses, which utilized slate. The Spanish barrel tiles were used over the seams and ridges of the roofs.

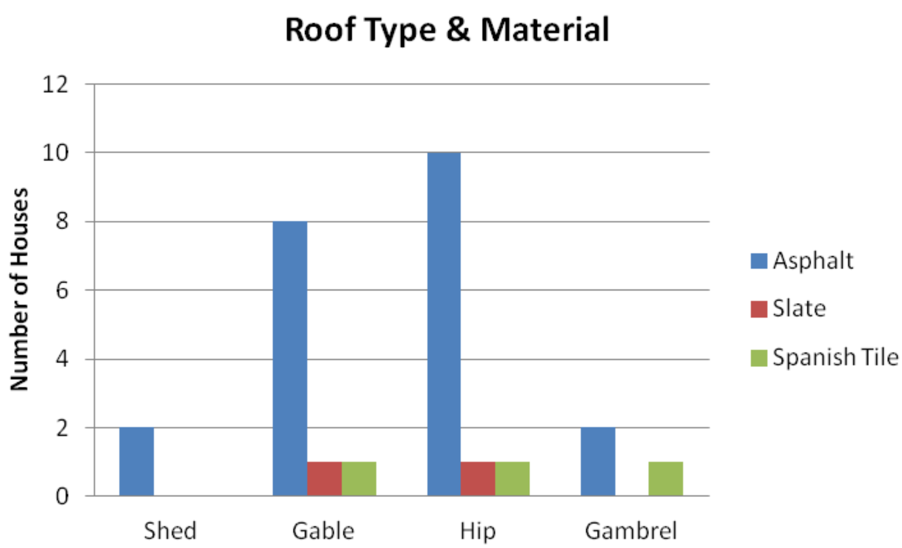


Figure 4-10. Gentilly Terrace roof type and material results

Walls

The exterior wall materials documented were limited to four: brick, stone, horizontal wood siding and stucco. Horizontal wood siding was the most prevalent by far, at fifty-nine percent. In both residences where stucco was used, it was paired with the horizontal wood. Fourteen of the twenty houses used wood, while seven had built with brick.

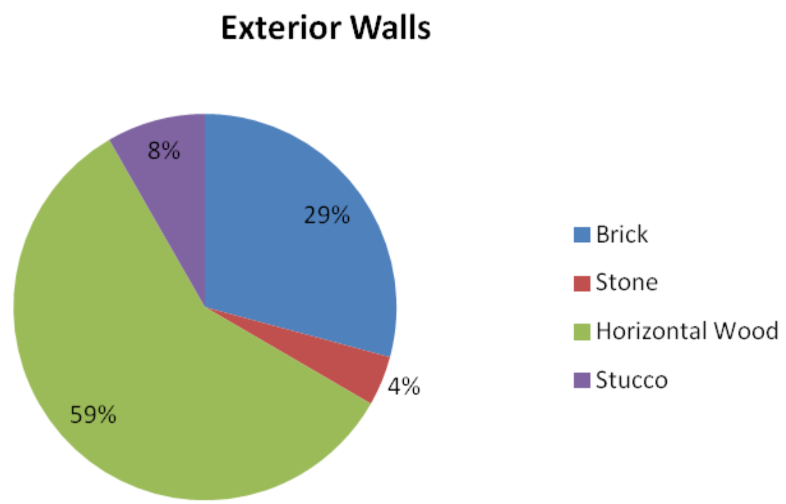


Figure 4-11. Gentilly Terrace exterior wall material results

Foundation

Piers was the most popular type of foundation method utilized, with brick as the most used material, for both piers and enclosed crawl spaces. Twenty-five percent of the houses in this area were slab-on-grade, thereby refraining from elevating the structure off the ground. No residences with basements were surveyed in Gentilly Terrace.

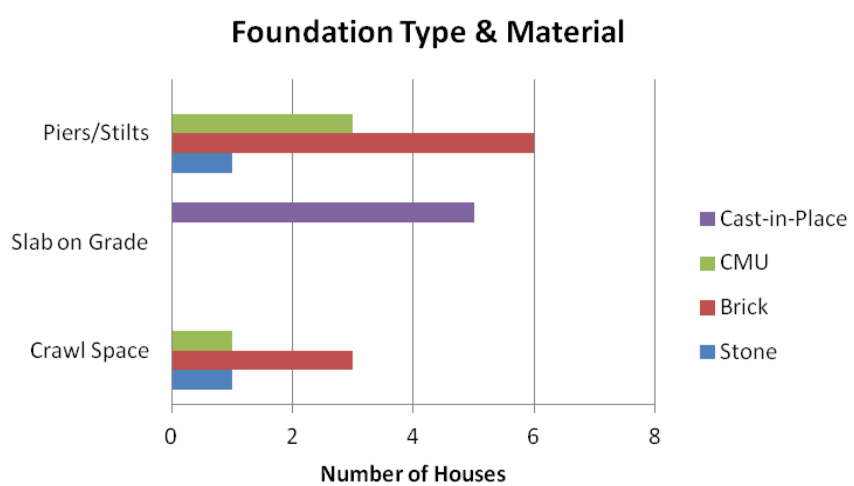


Figure 4-12. Gentilly Terrace foundation type and material results

Saint Claude

Saint Claude was the fourth neighborhood to be surveyed and the first to have a significant portion of the area rebuilt by a not-for-profit organization. The area is specifically known as Musician's Village, built by Habitat for Humanity (see Figure 4-13) in the center of the neighborhood. The neighborhood was classified as high flood, medium vulnerability. Most of the houses in the area were either cottages or shotgun style, and while portions of Saint Claude had been repaired, there were empty houses on every street that were falling deeper into disrepair.


A


B

Figure 4-13. Saint Claude houses. A) typical shotgun house and B) one portion of Musicians Village (photographs by author)

Roof

In the Saint Claude neighborhood flat, gable, hip and gambrel roofs were used on the surveyed residences. The roofing type of choice was gable roof, with seventy-five percent of the houses using this. All twenty of the houses reviewed used asphalt shingles, with three utilizing slate or Spanish barrel tiles for the seams and ridges. This was the only neighborhood where every house surveyed incorporated asphalt shingles on the roof.

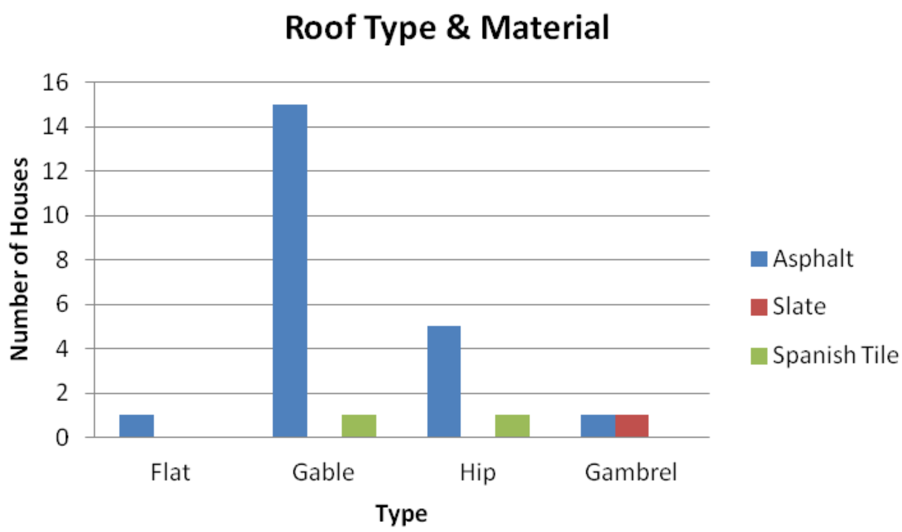


Figure 4-14. Saint Claude roof type and material results

Walls

For the exterior wall materials, nineteen of the twenty houses used horizontal wood siding, either as the sole cladding or in combination with brick or stucco. One house utilized only brick as the exterior material.

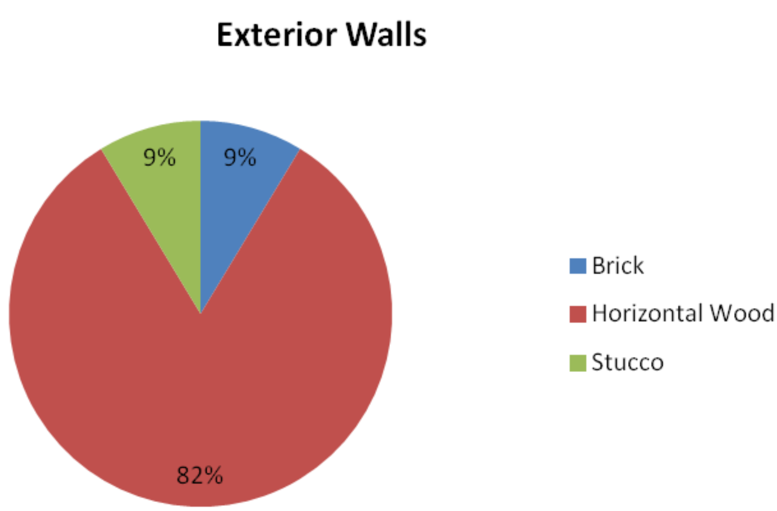


Figure 4-15. Saint Claude exterior wall material results

Foundation

The foundation type most documented in the Saint Claude neighborhood was piers/stilts, using either brick or CMU. Three of the houses surveyed were built slab-on-grade, while the remaining four utilized an enclosed crawl space of either brick or CMU. Saint Claude was the first neighborhood studied to introduce stone as a foundation material.

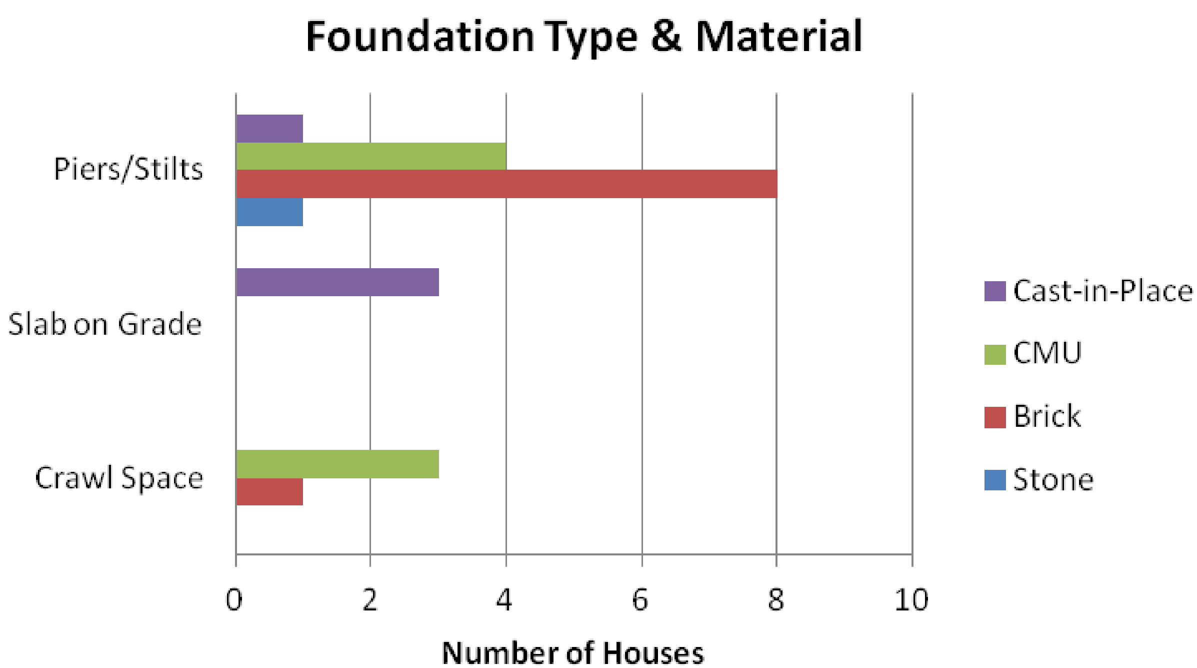


Figure 4-16. Saint Claude foundation type and material results

Lower Ninth Ward

The Lower Ninth Ward was the fifth neighborhood that was surveyed for this study. This area was classified as high flood, medium vulnerability, but it was one of the areas that experienced the worst of the flooding; in the GIS study for the Lower Ninth Ward, it is possible to see the broken levees and the water pouring into the neighborhood. As a result of the extensive flooding and lack of overall income, this area was chosen to be the focus of the Make It Right Foundation. As a result of the stipulations for design that were mentioned previously, many of the houses were comprised of the same materials, though configured in completely different ways. The Lower Ninth Ward has also been the recipient of services performed by several other relief organizations. The most prevalent house style is the shotgun, which is classic vernacular in Louisiana. In some instances it has been reinterpreted, while still remaining true to the defining characteristics.

A

B

Figure 4-17. Houses in the Lower Ninth Ward (photographs by author)

Roof

All of five roof types were represented in the houses surveyed, though gable, hip and shed were the most frequently occurring. Only two roof materials were noted: asphalt shingles and corrugated metal. In the Lower Ninth Ward, the roofing material used was dependent solely on the organization that rebuilt the structure. The Make It Right houses all utilize metal roofs for sustainability and storm resistance, while the other structures incorporated asphalt. In the survey group there were fourteen metal roofs and six with asphalt shingles.

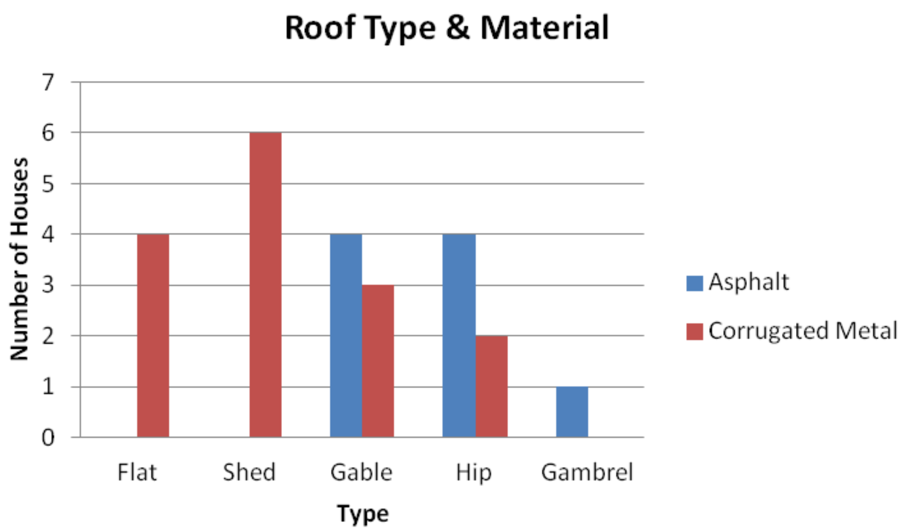


Figure 4-18. Lower Ninth Ward roof type and material results

Walls

For the exterior wall materials in the Lower Ninth Ward, only three options were documented: cement fiber board, horizontal wood siding and aluminum siding. The most frequently occurring was cement fiber board, which was used on thirteen of twenty houses, or sixty-five percent. Aluminum siding was only used in one instance.

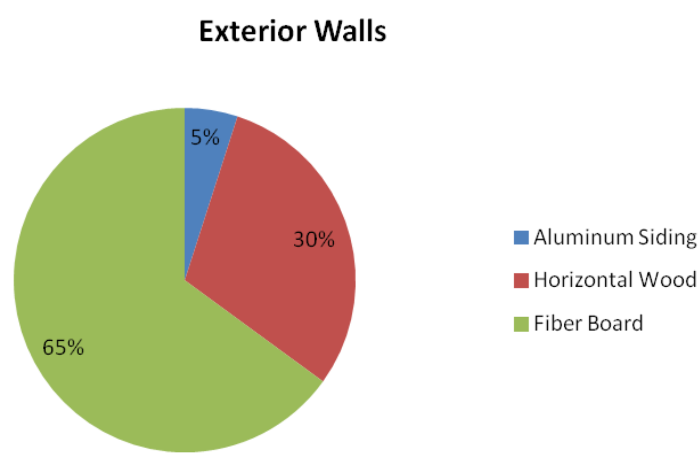


Figure 4-19. Lower Ninth Ward exterior wall material results

Foundation

All of the houses reviewed in the Lower Ninth Ward were elevated off of the ground, many to a height such that the space underneath could be used to park cars. All but one of the twenty houses were built on piers, the single remaining house utilized an enclosed crawl space. Of the houses on piers, the most popular material was cast-in-place, with nine houses. The other options included: CMU, pressure-treated wood, brick and steel. This neighborhood was the only section looked at that incorporated steel into the foundation systems.

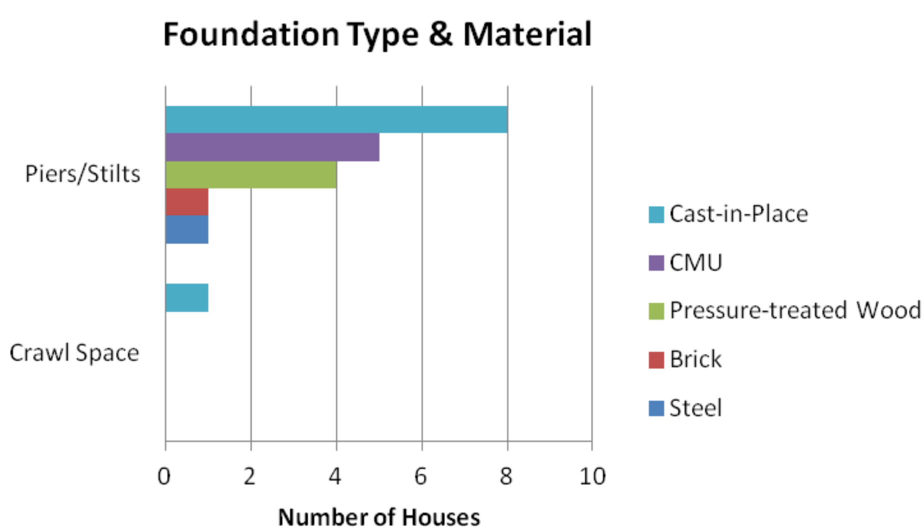


Figure 4-20. Lower Ninth Ward foundation type and material results

Holy Cross

The neighborhood of Holy Cross was the sixth and final area investigated for the New Orleans study. It was the only neighborhood that was categorized as high flooding, high vulnerability. Similar to the Lower Ninth Ward, it experienced some of the most intense flooding. The reconstruction of Holy Cross was only partially complete at the time of the field study, some areas were in the midst of construction, but many houses had been abandoned and left to fall in further disrepair. As previously mentioned, this neighborhood was also the beneficiary of a design competition to generate sustainable houses, an apartment complex and a community center.


A


B

Figure 4-21. Holy Cross houses (photographs by author)

Roof

Four roof types were identified in the survey group: shed, gable, hip and gambrel. The most prevalent type was gable, with twelve houses, followed by hip with six. Both shed and gambrel occurred only once each. Asphalt shingles were used on seventeen of the twenty houses. Slate, corrugated metal and Spanish barrel tiles made up the remaining roof materials noted.

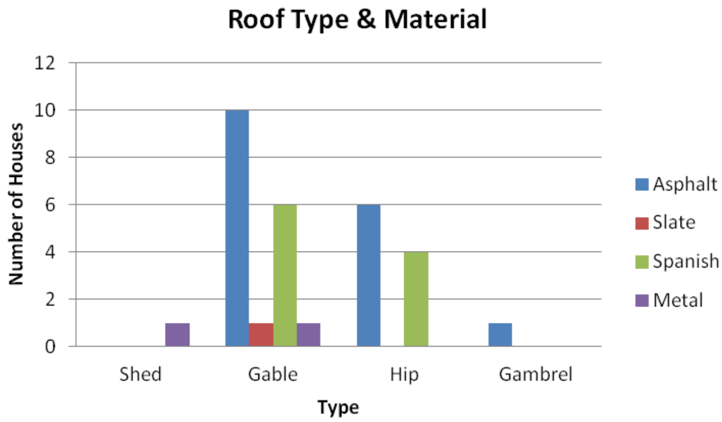


Figure 4-22. Holy Cross foundation type and material results

Walls

Horizontal wood siding was the most popular exterior wall material at fifty-four percent, followed most closely by brick at twenty-one percent. Holy Cross was the neighborhood with the second greatest variety in exterior wall material options, behind Navarre. Many of the material were used in combination with the wood siding or brick. Here material's remained very true to the style of house, such as horizontal wood siding on shotgun houses.

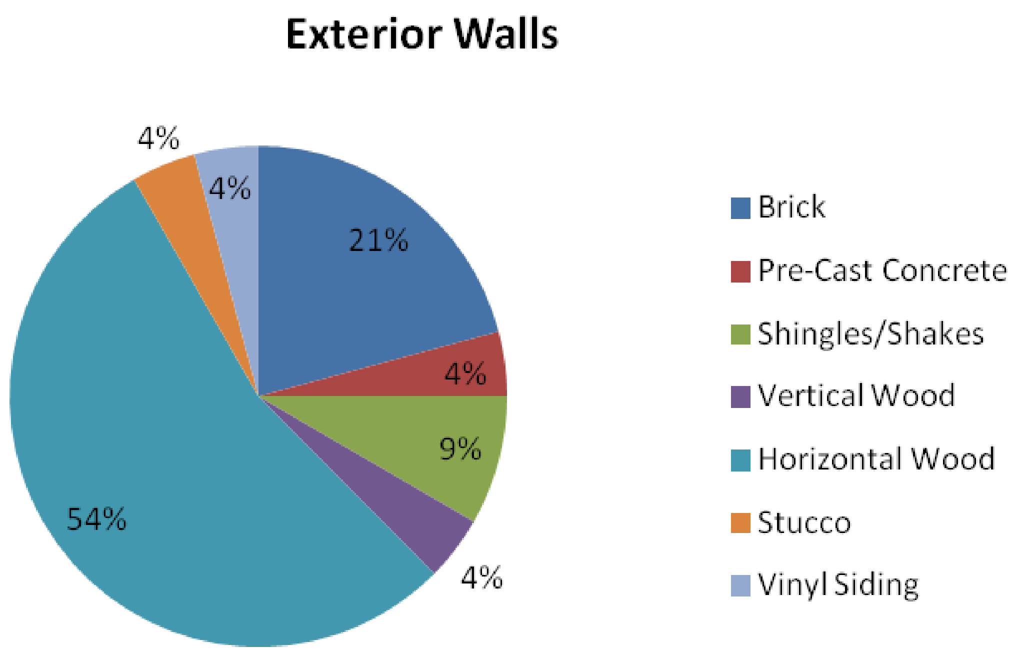


Figure 4-23. Holy Cross exterior wall material results

Foundation

All but two of the study houses utilized elevated foundation types, in the form of piers or an enclosed crawl space. CMU piers were the most frequently occurring with eight houses, though cast-in-place, brick and stone were also documented. Three houses had crawl spaces in either cast-in-place or brick.

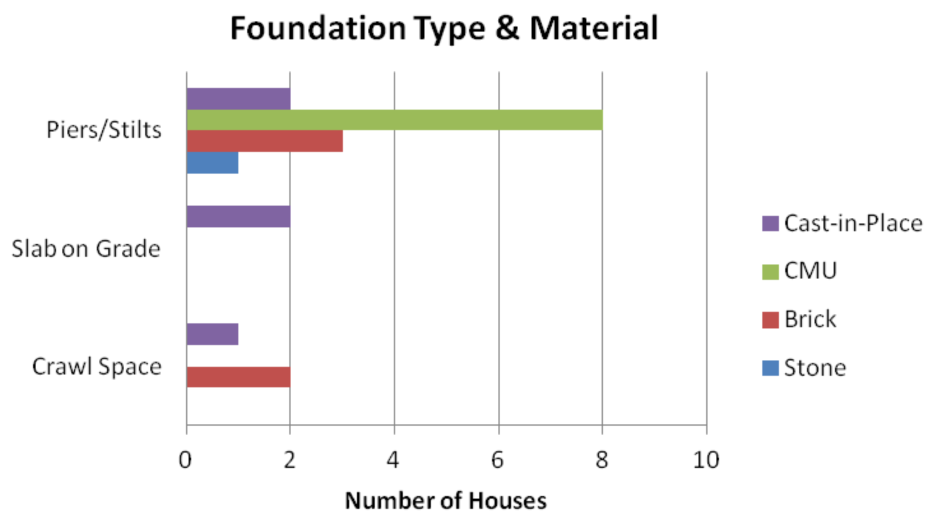


Figure 4-24. Holy Cross foundation type and material results

The information that was collected and synthesized from each of the neighborhoods was then analyzed to determine the life cycle cost of each material, and later used in quality modeling.

Sustainable Index

The Sustainable Index was comprised of all of the credits from three leading rating systems: LEED, Green Globes, and the Florida Green Building Coalition that were dependent in some capacity on the exterior envelope. When the credits were than compared against each of the exterior envelope elements, it was determined that the roofing systems and exterior wall materials are eligible for potentially gaining the most credits overall as seen in Figure 4-25. The range of points for the index was zero to sixteen. For roofing materials category, both corrugated and sheet metal earned the most points with thirteen. Wood shakes, slate, clay tiles and Spanish barrel tiles each have the potential of twelve points. The built-up roof was deemed the least sustainable at seven points, for this index. For the exterior wall systems, the potential earnable credits ranged from twelve to sixteen. The categories that scored the highest were the concretes: pre-cast and CMU, the metals: steel and aluminum sidings, and cement fiber

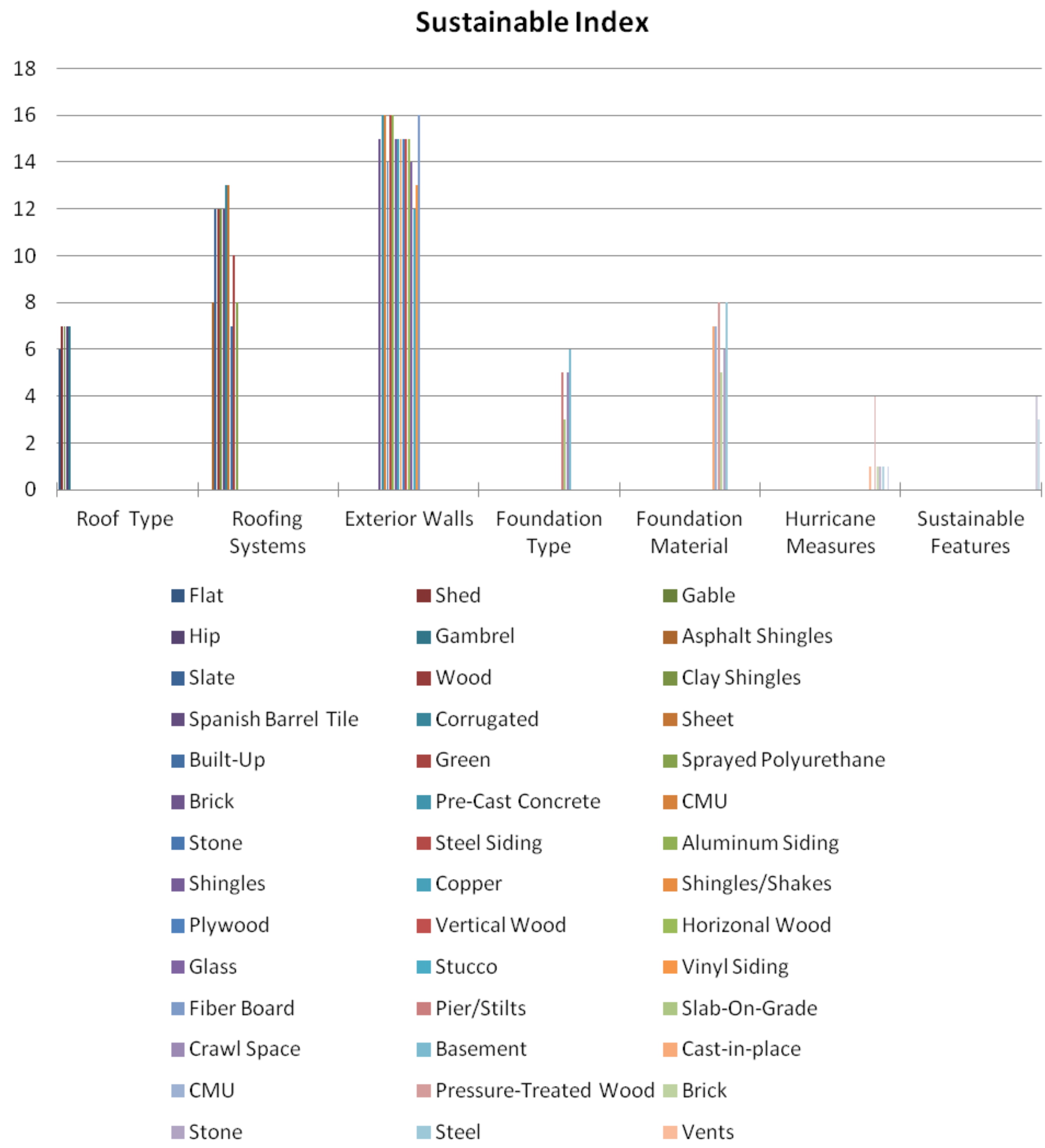


Figure 4-25. Sustainable Index points by exterior envelope elements

board. Stucco was deemed the least sustainable. The foundation materials that were most sustainable were pressure-treated wood and steel, both with the potential to impact eight credits. The incorporation of the Florida Green Building Coalition was aimed at analyzing how beneficial disaster mitigation measures would be in the goal of developing sustainable housing, but as seen in Figure 4-25, most of the hurricane measures may only earn one credit, with fences potentially impacting four credits.

Life Cycle Cost

The life cycle cost was determined for each of the materials that were identified in houses in the New Orleans field study. The factors included were:

- Initial Cost
- Annual Maintenance
- Repairs
- Replacement

The time value of money was also considered for the sake of accuracy. Three separate life cycle costs were performed for roof materials, exterior wall materials and foundation type and material. The full spreadsheets may be seen in Appendix H.

Roof Systems

Five roof systems were evaluated for life cycle cost: asphalt shingles, slate, clay tile, Spanish barrel tile (or mission tile) and corrugated metal. The annual maintenance for all systems was restricted to inspections and the only repair costs were noted for the three tile options, for replacement of broken tiles at some point during the life of the roof. All three tile options had life expectancies that exceeded the intended life of the house. Asphalt shingles required two replacements, while corrugated metal needed one. Asphalt shingles had the lowest initial cost at $2,513.19, while Spanish tile was the highest at $11,554.89. Even with two replacements, asphalt shingles had the lowest life cycle cost at $9,551.10, while Spanish tile had the highest at $16,806.45.

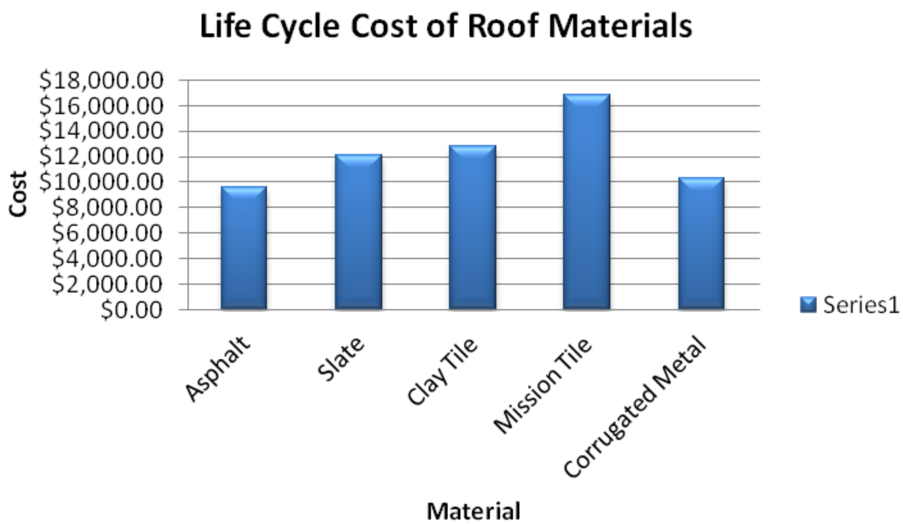


Figure 4-26. Life Cycle Cost roof results

Exterior Walls

Life cycle cost analysis was performed for a variety of exterior wall materials, including:

- Brick
- Stone
- Concrete
- Aluminum Siding
- Shingles/Shakes
- Vertical Wood Siding
- Horizontal Wood Siding
- Stucco
- Vinyl Siding
- Cement Fiber Board

The annual maintenance included professional cleaning and repainting for certain systems. Not all materials required annual maintenance such as: pre-cast concrete, stucco and vinyl siding. Only two materials required replacing: aluminum siding and wood shingles/shakes. The material that had the lowest initial coast was vinyl siding at $3,160.30, while the highest was pre-cast concrete at $44,122.00. These two particular materials did not incur annual maintenance, repair or replacement costs, so their life cycle costs were the same as the initial costs. They also maintained their respective positions as least and most expensive for life cycle cost (see Figure 4-27).

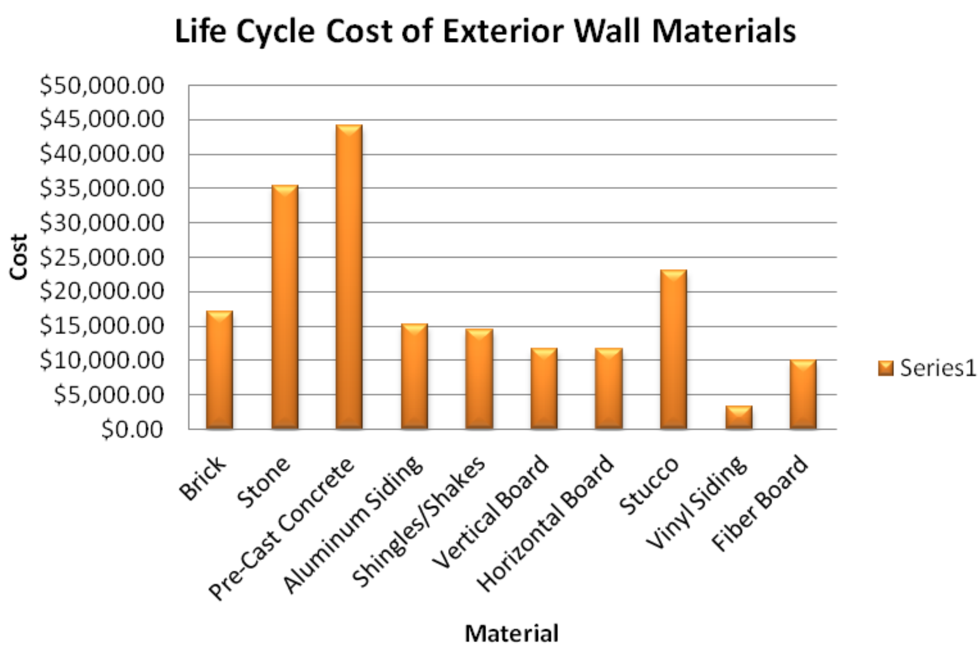


Figure 4-27. Life Cycle Cost exterior wall results

Foundation Systems

The possible combinations between foundation type and material were numerous. Fourteen different options were documented in New Orleans:

- Piers, cast-in-place
- Piers, CMU
- Piers, pressure-treated wood
- Piers, brick
- Piers, stone
- Piers, steel
- Slab-on-grade
- Crawl space, cast-in-place

- Crawl space, CMU
- Crawl space, pressure-treated wood
- Crawl space, brick
- Crawl space, stone
- Basement, CMU
- Basement, Brick

The annual maintenance calculated for the foundations included the necessary painting or sealant necessary. This was calculated by taking the number of times painting would need to occur (between five and ten years, depending on the material) and dividing the total cost by the life of the building. The materials without maintenance costs were: cast-in-place piers, steel piers, slab-on-grade, and cast-in-place crawl space. The steel piers would need to be re-sealed, but the process needed to be done only once during the life of the building, so that cost was incorporated into repairs. The foundations utilizing pressure-treated wood would need to be replaced after thirty years.

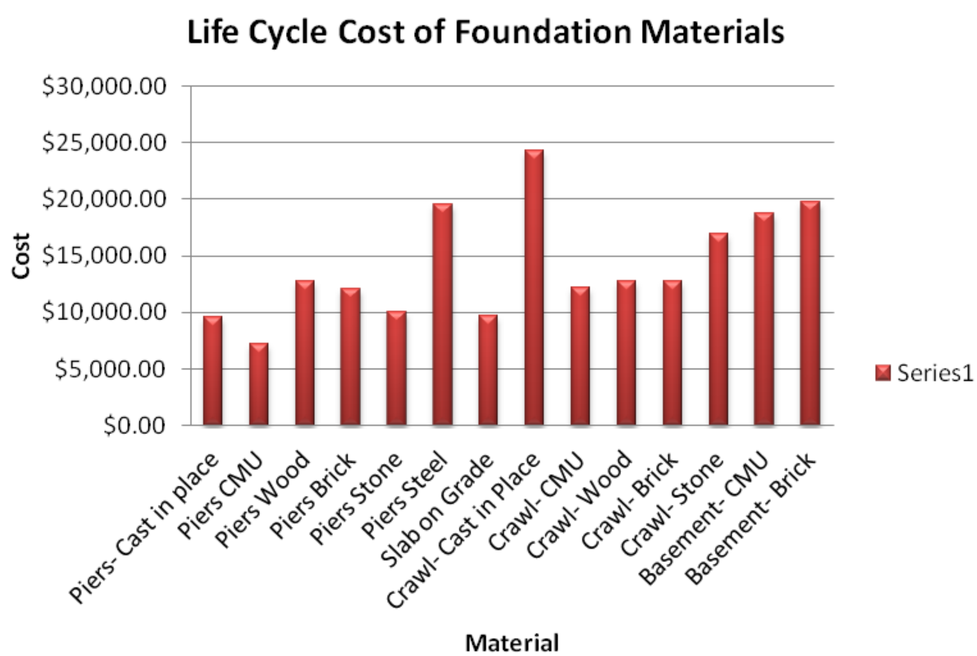


Figure 4-28. Life Cycle Cost foundation results

CMU piers are the lowest in initial cost at $6,716.37, while cast-in-place concrete is the most expensive initially at $24,229.37. Life cycle cost for CMU piers is $7,147.11, which allows it to maintain its position as the most affordable. The LCC for cast-in-place crawl space is the same as the initial cost, but it remains the most expensive option.

Quality Modeling

Once the life cycle cost calculations were complete, all of the information gathered for that, plus the sustainable index and field study results were used to perform quality modeling on all material options. The nine characteristics derived from the original FAST diagram were weighted from one to five based on perceived importance for the particular occasion of a natural disaster in the region of New Orleans, Louisiana. One was the least important, five the most. The weighting was as follows:

- Schedule: 2
- Labor Intensity: 1
- Initial Cost: 4
- Life Cycle Cost: 5
- Durability: 4
- Maintenance: 2
- Hurricane Resistance: 5
- Sustainability: 3
- Historical Vernacular: 4

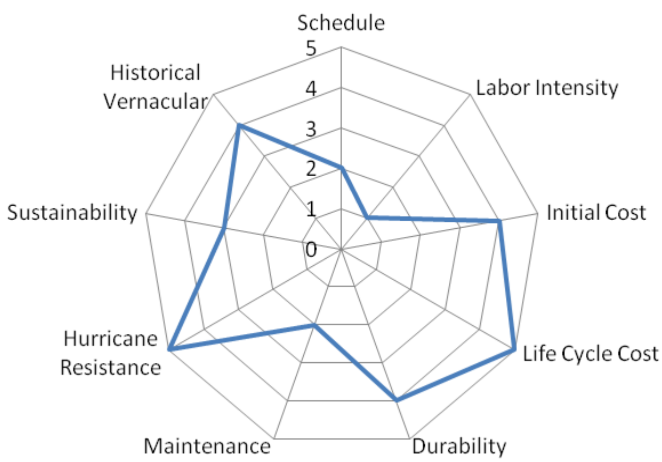


Figure 4-29. Radar diagram of characteristics for quality modeling

Life cycle cost and hurricane resistance were identified as the most significant factors and were therefore awarded the highest weight. Durability is the actual life span of the building, which relates closely with sustainable design, while the sustainability characteristic represents how the system or material faired against the sustainable index. All of the weighted characteristics may be seen in comparison to each other in the Radar diagram in Figure 4-29.

Once the characteristics were weighted they were compared to each other factor to be given and overall weight, which was multiplied to each material option. The overall weights for each characteristic were as follows:

- Schedule: 2
- Labor Intensity: 1
- Initial Cost: 10
- Life Cycle Cost: 15
- Durability: 10
- Maintenance: 2
- Hurricane Resistance: 15
- Sustainability: 4
- Historical Vernacular: 10

These numbers were multiplied by the values assigned to each material option via the Likert scales, to give an overall weight for each material option in each characteristic. These values were added together to give an overall total to each material that could be compared to all of the other material options. The top three options for roof material were:

- Metal: value (280), sustainable index (13)
- Slate: value (265), sustainable index (12)
- Clay: value (258), sustainable index (12)

For exterior wall materials:

- Brick: value (272), sustainable index (15)
- Cement Fiber Board: value (269), sustainable index (16)

- Horizontal Wood Siding: value (250), sustainable index (15)

For foundation types and materials:

- Cast-in-Place Piers: value (291), sustainable index (11)
- CMU Piers: value (282), sustainable index (11)
- Brick Piers: value (255), sustainable index (9)
- CMU Crawl Space: value (254), sustainable index (11)

Sustainability and durability or longevity were incorporated into the overall quality model, but for ease of comparison the raw score from the sustainable index was also noted. Following the quality modeling, an "ideal" model was developed with the highest ranking option in each exterior envelope category: metal roof, brick exterior walls, cast-in-place piers, for a total of 843 points, a total cost of $36,953.86 and forty-two points on the sustainable index.

Comparison: Quality Model and Neighborhood Field Study

The final step in analysis was to compare the ideal model to each neighborhood model for quality model values, total life cycle cost and sustainable index points.

Navarre

For the first neighborhood reviewed, Navarre, the most often documented roof was gable asphalt, exterior wall material was horizontal wood siding and foundation was slab-on-grade. According to the life cycle cost calculations the total amount for these three systems is $30,944.22. This combination scored 722 points in the quality model, and earned thirty-five points on the sustainability index. Implementing the ideal model would cost an additional $6,009.64 and earn seven additional sustainability points.

Lakeview

Lakeview, the second neighborhood, most frequently utilized hip asphalt shingle roofs, horizontal wood siding for the exterior walls, and cast-in-place enclosed crawlspace for the foundation system. Collectively, this cost $33,462.95, earned a value of 708 on the quality model and thirty-seven points on the sustainability index. Implementation of the ideal model would cost an additional $3,491.91 and increase the sustainable points by five.

Gentilly Terrace

The main roofing material chosen for Gentilly Terrace was asphalt shingles on a gable roof. Horizontal wood siding was chosen for the exterior walls, while brick piers were employed for the foundation type and material. This material combination costs $33,334.01, has a quality model value of 740, and a sustainability index value of thirty-five points. Switching to the ideal model would increase costs by $3,619.85 but raise sustainability points by seven.

Saint Claude

The fourth neighborhood, Saint Claude, most frequently used asphalt shingles on a gable roof, horizontal wood siding for the exterior walls, and cast-in-place piers for the foundation. Collectively, these materials earned a quality model score of 776, cost $30,824.59 and gained thirty-seven points of the sustainability index. Converting to the ideal model would cost an additional $6,129.27 and earn five sustainability points.

Lower Ninth Ward

The Lower Ninth Ward produced results that differed from every other neighborhood surveyed. The most frequently documented materials systems were corrugated metal gable roof, cement fiberboard walls and cast-in-place piers foundation. This combination cost $29,841.32 (the second to lowest amount), earned a value of 840 points in the quality model and garnered forty-three sustainability points. Implementing the ideal model would cost an additional $7,112.54 and decrease the sustainability points by one.

Holy Cross

The final neighborhood reviewed, Holy Cross used asphalt shingles on gable roofs, horizontal wood siding on exterior walls, and CMU pier foundations. Collectively, this combination cost $28,397.21, gained a quality model value of 765 and impacted thirty-seven sustainability credits. The ideal model would increase costs by $8,556.65 and raise potential sustainability points by five.

New Orleans as a Whole

Collectively, the neighborhoods surveyed consistently used asphalt, gable roofs with horizontal wood siding on the exterior walls and some sort of pier foundation. The most popular foundation type and material changed with each neighborhood. Not all of the houses or even neighborhoods strictly adhered to these options; some like the Lower Ninth Ward utilized many different materials and still came out as one of the most economical options. The reasoning for the materials selected cannot be defined solely through this analysis and may only be determined with more information from the designers, homeowners and builders.

CHAPTER 5
CONCLUSIONS

Factors In Decision-Making

The final comparisons of the combinations of material systems by neighborhood revealed information on the decision making process when rebuilding after a natural disaster. Five of the neighborhoods chose asphalt shingle roofs, even though they have the highest maintenance cost, lowest sustainability and only average hurricane resistance. Asphalt shingles do however, have the lowest initial and life cycle costs. Horizontal wood siding and brick were significantly more popular than any of the other cheaper, more sustainable options. Wood siding and brick did both rank high with historical vernacular. The foundation systems were different from one neighborhood to another. The conclusions to be gathered from this information is that historical vernacular and initial cost are the most heavily weighted factors in selection of exterior envelope systems.

The neighborhood that defied these conclusions was the Lower Ninth Ward. Many of the houses documented were rebuilt by the Make It Right Foundation, which defined an acceptable materials palette based on sustainability, durability and life cycle cost prior to engaging designers and architects for the projects (Home Features and Materials 2009). The result of this approach was a series of houses with a combination of materials that came within three points of the ideal quality model option, and beat the ideal model on the sustainability index, while costing approximately $7,000 less. The only material option that was different than the ideal was cement fiberboard, which has a life expectancy of half what brick is, making it ideal in all by durability.

Rapid Recovery Versus Productive Reconstruction

The constant struggle in a region after a natural disaster is between rebuilding with as much speed as possible and pausing to digest the issues that were revealed. Each person and organization involved in the reconstruction process has an opinion of the balance between the two, but another danger also exists: pausing for too long. In this case, issues are no longer being reviewed for improvement, but rather they are being pushed aside and not dealt with.

Moving between neighborhoods during the New Orleans field study unveiled some interesting observations. For the most part, the neighborhoods that had a higher income (Lakeview, Gentilly Terrace) have been repaired successfully, or are currently in the process of reconstruction. These homes have been rebuilt as the owners have had funds available, although some did possess flood insurance. There were no blatantly abandoned residences in these neighborhoods. Likewise, the neighborhoods with notably less income (the Lower Ninth Ward, Holy Cross) are moving more slowly toward full recovery but making considerable progress. The literature revealed that the areas hit the hardest were typically rented, with little or no insurance to cover the expenses incurred by the residents as the result of flood damage. These areas were popularized by national media, and several non-profit organizations arrived to help in addition to government funding. The surprising revelation was that areas that are still only medium vulnerability such as Saint Claude, but have significantly less disposable income than other neighborhoods, are falling in the cracks when it comes to reconstruction. Several abandoned structures were observed as being in the process of crumbling and the overall atmosphere of the area was less than welcoming. There is a great risk of the neighborhoods which were at one point were in the middle of the social range falling into such disrepair that they become the new highly vulnerable neighborhoods. This relates back to the broken window theory, which basically claims that people in a neighborhood will maintain the status quo (Holbein 2009). Some neighborhoods such as the Lower Ninth Ward have used this reconstruction process as an opportunity to engage the community, upgrade the neighborhood and produce a new “normal” that feels both safe and inviting. It would be unfortunate to see in few years time that the vulnerable neighborhood did not in fact disappear, but rather relocated.

Overall Process

The process for gathering and synthesizing information provided interesting insights into the sustainability and materiality of the recovering New Orleans neighborhoods. Each of the analytical tools processed separate information from the field study, but all worked together to produce the data needed for the quality model factors. The quality model weights could also be adjusted for different situations or to explore other influences in decision-making without skewing the original data. Overall, the tools provided a detailed comparison of six neighborhoods, in addition to a general snapshot of the reconstruction of the New Orleans Parish.

Further Research

Several areas exist for further research. One option considers running the quality model additional times while altering the weights of the characteristics to relate to the specific needs of each neighborhood. This would either produce entirely different results with each reweighting or it would reinforce the options selected for the ideal model. Additionally, this would allow an ideal model for each area to be determined, based on what was most important for each group of residents. Another study looking at the most popular material selections for the six neighborhoods combined would reveal the standard for the greater New Orleans area. More neighborhoods could always be integrated for wider diversity. Also, the field study could be performed in other regions that have experienced natural disaster damage to showcase whether different factors influence the decision-making of exterior envelope elements in other regions.

One idea that was not explored in the review of the literature or through the analysis process is whether a model could be utilized in preparing for a natural disaster. One preliminary idea is that the quality model could be used to select material options that would be ideal for the reconstruction process based on each city's disaster preparedness and recovery plans. This might reduce the lead time necessary to procure some materials, as well as limiting the time required for planning prior to reconstruction.

APPENDIX A
BUILDING CODE ANALYSIS

The analysis of the Florida Building Coded involved the line-by-line study of each chapter that pertained to the exterior envelope as it was defined for this study (roof, exterior walls and foundations) and all of the chapters relating to materials included in the New Orleans field study. The information on the general systems was utilized to define the parameters for the model house for life cycle cost analysis and quality modeling and the material information was imperative for selecting the material for life cycle cost analysis that could withstand a hurricane. For this study, only the regulations that pertained directly to the systems or materials were analyzed; the assumption was made that all systems and materials were built to manufacturers and inspectors specifications. The following chapters were analyzed over the course of this study:

- Chapter 3: Use and Occupancy Classification
- Chapter 4: Special Detailed Requirements Based on Use and Occupancy
- Chapter 14: Exterior Walls
- Chapter 15: Roof Assemblies and Rooftop Structures
- Chapter 16: Structural Design
- Chapter 18: Soils and Foundations
- Chapter 19: Concrete
- Chapter 20: Aluminum
- Chapter 21: Masonry
- Chapter 22: Steel
- Chapter 23: Wood

APPENDIX B
SUSTAINABLE METRICS ANALYSIS

A preliminary review of the current rating systems that exist to measure the sustainability of a structure revealed that while each of the rating systems showcases different aspects of the exterior envelope, no one of these rating systems encompasses all of the ways in which this envelope may contribute to the overall sustainability of a building. The solution was to analyze three leading rating systems: LEED, Green Globes and the Florida Green Building Coalition to compile all of the credits that may be impacted by the shell of the structure. Between the three, twenty-nine credits were discovered, some shared between all of the rating systems and some unique to one.

APPENDIX C
LOUISIANA HOUSE SURVEY FORM

Neighborhood: ____

House: ______________________ **House Type:** ______________________

Street Name: ____

Roof Type:

Flat	Shed	Gable	Hip	Gambrel

Roof Finish Material:

Shingles:	Asphalt	Slate	Wood	
Tiles:	Clay			
Metal:	Corrugated	Sheet		
Other:	Built-up	Green	Sprayed Polyurethane	

Exterior Siding:

Masonry:	Brick	Pre-Cast Concrete	CMU	Stone
Metal:	Steel Siding	Aluminum Siding	Shingles	Copper
Wood:	Shingles/Shakes	Plywood	Vertical	Horizontal
Other:	Glass	Stucco	Vinyl Siding	Fiber board

Foundation Type:

Piers/Stilts	Slab-on-grade	Crawl Space	Basement

Foundation Material:

Cast-in-place	CMU	Pressure-treated Wood

Applicable Hurricane Codes: ____

____

Sustainable Measures: ____

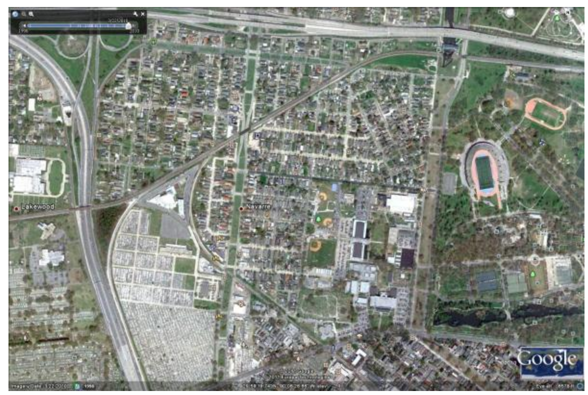
____

APPENDIX D
GIS NEIGHBORHOOD REVIEW

A.

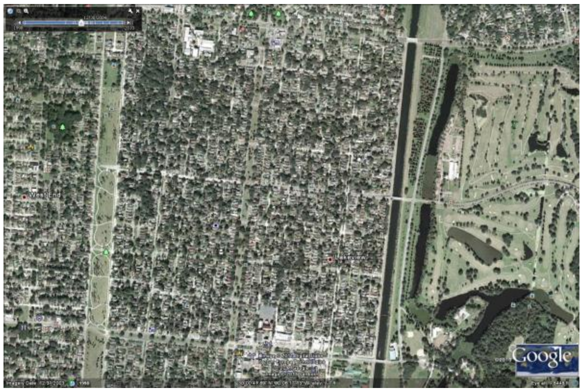
B.

C.



D.

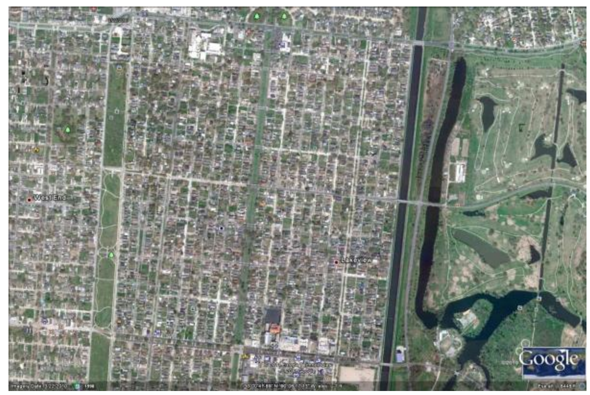
Figure D-1. Series of images of the New Orleans neighborhood Navarre collected from Google Earth. A) taken on December 30, 2004; eight months prior to Hurricane Katrina B). taken on August 30, 2005; one day after Hurricane Katrina C) taken on June 12, 2006; nine months after Hurricane Katrina and D) taken on March 22, 2010; four and a half years after Hurricane Katrina. (©2011 Google, ©2011Europa Technologies, ©2011 Digital Globe, ©2011 Sanborn, Image: NOAA)



A.

B.

C.

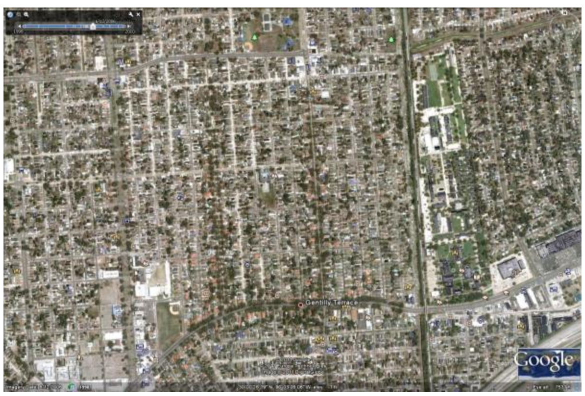


D.

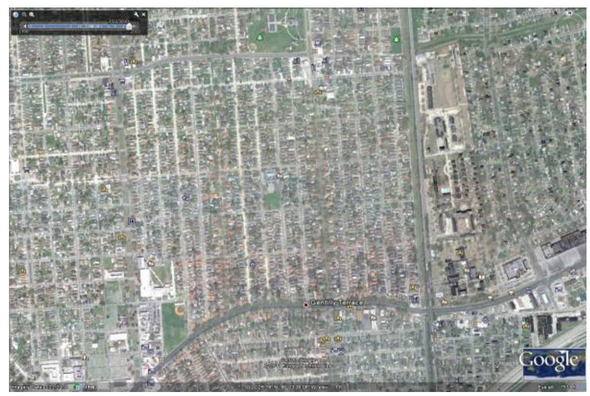
Figure D-2. Series of images of the New Orleans neighborhood Lakeview collected from Google Earth. A) taken on December 30, 2004; eight months prior to Hurricane Katrina B). taken on August 30, 2005; one day after Hurricane Katrina C) taken on June 12, 2006; nine months after Hurricane Katrina and D) taken on March 22, 2010; four and a half years after Hurricane Katrina. (©2011 Google, ©2011Europa Technologies, ©2011 Digital Globe, ©2011 Sanborn, Image: NOAA)

A.

B.

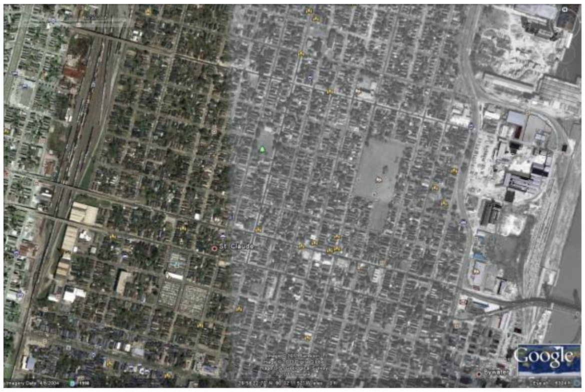


C.



D.

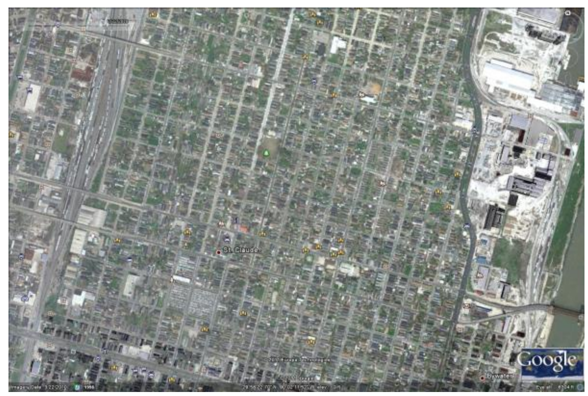
Figure D-3. Series of images of the New Orleans neighborhood Gentilly Terrace collected from Google Earth. A) taken on December 30, 2004; eight months prior to Hurricane Katrina B). taken on August 30, 2005; one day after Hurricane Katrina C) taken on June 12, 2006; nine months after Hurricane Katrina and D) taken on March 22, 2010; four and a half years after Hurricane Katrina. (©2011 Google, ©2011Europa Technologies, ©2011 Digital Globe, ©2011 Sanborn, Images: US Geological Survey, NOAA)



A.

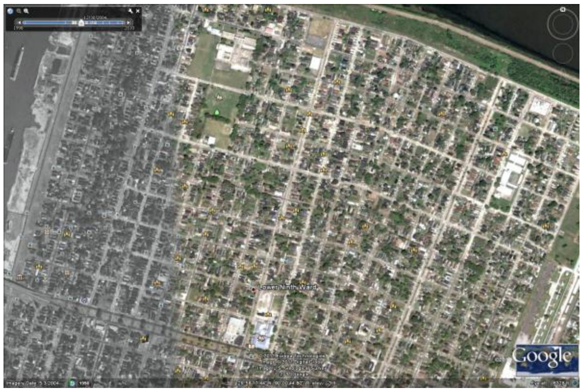
B.

C.

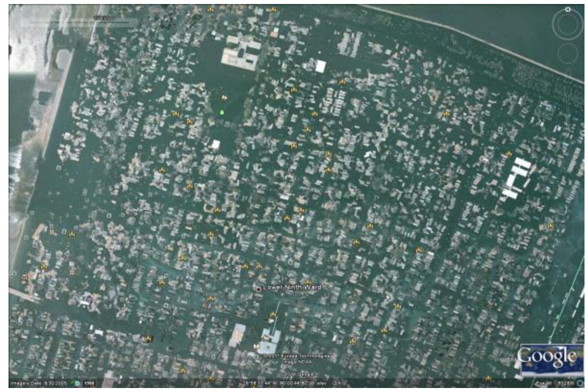


D.

Figure D-4. Series of images of the New Orleans neighborhood Saint Claude collected from Google Earth. A) taken on December 30, 2004; eight months prior to Hurricane Katrina B). taken on August 30, 2005; one day after Hurricane Katrina C) taken on June 12, 2006; nine months after Hurricane Katrina and D) taken on March 22, 2010; four and a half years after Hurricane Katrina. (©2011 Google, ©2011Europa Technologies, ©2011 Digital Globe, ©2011 Sanborn, Images: US Geological Survey, NOAA)

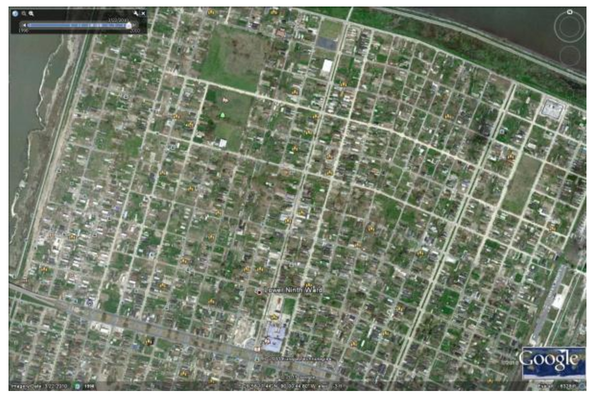


A.



B.

C.



D.

Figure D-5. Series of images of the New Orleans neighborhood the Lower Ninth Ward collected from Google Earth. A) taken on December 30, 2004; eight months prior to Hurricane Katrina B). taken on August 30, 2005; one day after Hurricane Katrina C) taken on June 12, 2006; nine months after Hurricane Katrina and D) taken on March 22, 2010; four and a half years after Hurricane Katrina. (©2011 Google, ©2011Europa Technologies, ©2011 Digital Globe, Images: US Geological Survey, NOAA)

APPENDIX E
FIELD STUDY IMAGES

Figure E-1. Images from the field study of the Lower Ninth Ward (photographs by author)

Figure E-2. Images from the field study of the Navarre neighborhood (photographs by author)

Figure E-3. Images from the field study of the Lakeview and Gentilly Terrace neighborhoods (photographs by author)

Figure E-4. Images from the field study of the Gentilly Terrace, Saint Claude and Holy Cross neighborhoods(photographs by author)

APPENDIX F
NEIGHBORHOOD SURVEY RESULTS

Neighborhood: Navarre			Roof type					Roofing Systems										Exterior Walls																Foundation Type				Foundation Material						Hurricane Measures										Sust.	
								Shingles			Tile		Metal		Other			Masonry				Metal				Wood				Other																									
House	Street	House Type	Flat	Shed	Gable	Hip	Gambrel	Asphalt Shingles	Slate	Wood	Clay Shingles	Spanish Barrel Tile	Corrugated	Sheet	Built-Up	Green	Sprayed Polyurethane	Brick	Pre-Cast Concrete	CMU	Stone	Steel Siding	Aluminum Siding	Shingles	Copper	Shingles/Shakes	Plywood	Vertical Wood	Horizonal Wood	Glass	Stucco	Vinyl Siding	Fiber Board	Pier/Stilts	Slab-On-Grade	Crawl Space	Basement	Cast-in-place	CMU	Pressure-Treated Wood	Brick	Stone	Steel	Vents	Gutters	Fence	Porch	Screened Porch	Roof Overhang	Metal Flashing	Grills of Masonry	Closed Eaves	Shutters	Exterior Screen System	Solar Panels
1	West Park Pl	Craftsman/Bungalow				X		X										X																		X					X			X	X	X	X								
2	West Park Pl	Colonial Plantation			X			X																					X						X			X						X	X			X	X						
3	Pontalba Street	Craftsman/Bungalow			X			X																		X			X							X					X			X	X					X					
4	Marshall Foch	Stilted Colonial			X			X															X									X		X					X							X	X								
5	Pontalba Street	Stilted Colonial			X			X																									X				X				X				X		X								
6	Florida	Spanish	X									X																			X					X		X						X	X	X	X	X							
7	Ada Place				X	X		X	X																				X								X		X							X			X	X					
8	Ada Place	Bungalow			X			X																							X		X	X				X																	
9	Florida					X		X																					X							X				X				X	X					X					
10	Memphis St	Plantation				X		X																					X						X			X							X		X								
11	Memphis St	Plantation				X		X				X							X				X												X			X						X			X		X						
12	Florida	Double Shotgun			X	X		X																					X						X			X							X					X					
13	General Diaz St	Colonial		X	X			X																					X						X			X																	
14	General Diaz St	Bungalow				X		X				X																					X		X			X																	
15	Hawthorne	Colonial			X						X												X											X		X					X				X	X					X				
16	Florida	Spanish			X	X						X																	X		X				X			X							X							X			
17	Florida			X	X	X		X																					X							X					X			X	X										
18	Florida	Double Shotgun			X			X																					X		X			X							X				X			X		X					
19	Florida				X			X											X																X			X																	
20	Florida	Spanish		X	X							X																			X			X				X							X							X			

Neighborhood: Lakeview			Roof type					Roofing Systems										Exterior Walls																Foundation Type				Foundation Material						Hurricane Measures										Sust.	
								Shingles			Tile		Metal		Other			Masonry				Metal				Wood				Other																									
House	Street	House Type	Flat	Shed	Gable	Hip	Gambrel	Asphalt Shingles	Slate	Wood	Clay Shingles	Spanish Barrel Tile	Corrugated	Sheet	Built-Up	Green	Sprayed Polyurethane	Brick	Pre-Cast Concrete	CMU	Stone	Steel Siding	Aluminum Siding	Shingles	Copper	Shingles/Shakes	Plywood	Vertical Wood	Horizonal Wood	Glass	Stucco	Vinyl Siding	Fiber Board	Pier/Stilts	Slab-On-Grade	Crawl Space	Basement	Cast-in-place	CMU	Pressure-Treated Wood	Brick	Stone	Steel	Vents	Gutters	Fence	Porch	Screened Porch	Roof Overhang	Metal Flashing	Grills of Masonry	Closed Eaves	Shutters	Exterior Screen System	Solar Panels
1	Marshall Foch					X		X										X																	X			X							X										
2	Marshall Foch	Spanish			X			X										X															X			X					X				X										
3	General Diaz				X			X										X													X					X		X							X			X							
4	Memphis St				X								X																		X		X		X	X		X												X					
5	Memphis St	Modern		X									X																X					X						X															
6	Vicksburg	Bungalow			X			X																									X			X			X															
7	Vicksburg	Ranch				X		X										X																	X			X							X										
8	Louis the 14th	Bungalow			X			X																									X			X		X						X	X										
9	Louisville	Traditional			X			X										X													X					X					X														
10	Louisville				X			X										X											X		X					X					X														
11	Colbert	Plantation				X		X																					X							X					X			X	X										
12	Colbert	Mission				X		X										X																		X			X						X					X			X		
13	Colbert				X	X		X										X																	X			X																	
14	Colbert	Double Shotgun		X	X	X		X													X								X							X		X						X	X										
15	Louisville	Plantation				X		X																					X					X				X							X				X						
16	Louisville	Florida			X			X																					X															X									X		
17	Memphis St	Cottage			X			X				X																	X					X							X				X	X									
18	Memphis St				X			X															X											X							X				X										
19	General Diaz	Farmhouse				X		X																					X							X		X						X	X	X		X							
20	General Diaz	Plantation			X			X																					X					X							X				X		X								

Neighborhood: Gentilly Terrace			Roof type					Roofing Systems										Exterior Walls																Foundation Type				Foundation Material						Hurricane Measures										Sust.	
								Shingles			Tile		Metal		Other			Masonry				Metal				Wood				Other																									
House	Street	House Type	Flat	Shed	Gable	Hip	Gambrel	Asphalt Shingles	Slate	Wood	Clay Shingles	Spanish Barrel Tile	Corrugated	Sheet	Built-Up	Green	Sprayed Polyurethane	Brick	Pre-Cast Concrete	CMU	Stone	Steel Siding	Aluminum Siding	Shingles	Copper	Shingles/Shakes	Plywood	Vertical Wood	Horizonal Wood	Glass	Stucco	Vinyl Siding	Fiber Board	Pier/Stilts	Slab-On-Grade	Crawl Space	Basement	Cast-in-place	CMU	Pressure-Treated Wood	Brick	Stone	Steel	Vents	Gutters	Fence	Porch	Screened Porch	Roof Overhang	Metal Flashing	Grills of Masonry	Closed Eaves	Shutters	Exterior Screen System	Solar Panels
1	Painters Street	Cottage			X			X													X															X						X		X	X										
2	Painters Street	Farmhouse		X	X			X																					X							X			X						X		X								
3	Venus Street	Double Shotgun				X		X																					X						X			X									X		X						
4	Venus Street	Cottage				X		X				X																	X					X							X							X							
5	Arts Street	Colonial				X		X				X						X																	X			X																	
6	Arts Street					X		X										X																		X					X					X									
7	Music Street	Cottage			X			X																					X					X					X									X	X						
8	Music Street	Cottage			X		X	X																					X					X					X						X				X		X				
9	Music Street	Craftsman/Bungalow					X	X				X																	X		X			X								X			X			X							
10	Music Street	Craftsman/Bungalow			X			X										X																X							X						X		X						
11	Mandeville	Arts & Crafts			X			X																					X							X					X			X	X		X								
12	Mandeville	Cottage			X			X																					X					X							X				X		X								
13	Spain Street	Cottage			X	X			X			X																	X					X							X				X			X							
14	Spain Street	Contemporary				X		X										X																	X			X						X	X										
15	Western	Cottage				X		X																					X					X							X														
16	Western			X		X		X										X											X						X			X								X		X							
17	Marigny	Farmhouse			X			X				X																	X						X			X							X		X								
18	Marigny	Cottage				X		X				X						X																		X					X			X	X		X								
19	De Montluzin	Greek Revival				X		X				X																	X					X							X							X							
20	De Montluzin	Double Cottage				X		X				X						X											X		X			X					X						X			X							

Neighborhood: Saint Claude			Roof type					Roofing Systems										Exterior Walls																Foundation Type				Foundation Material						Hurricane Measures										Sust.	
								Shingles			Tile		Metal		Other			Masonry				Metal				Wood				Other																									
House	Street	House Type	Flat	Shed	Gable	Hip	Gambrel	Asphalt Shingles	Slate	Wood	Clay Shingles	Spanish Barrel Tile	Corrugated	Sheet	Built-Up	Green	Sprayed Polyurethane	Brick	Pre-Cast Concrete	CMU	Stone	Steel Siding	Aluminum Siding	Shingles	Copper	Shingles/Shakes	Plywood	Vertical Wood	Horizonal Wood	Glass	Stucco	Vinyl Siding	Fiber Board	Pier/Stilts	Slab-On-Grade	Crawl Space	Basement	Cast-in-place	CMU	Pressure-Treated Wood	Brick	Stone	Steel	Vents	Gutters	Fence	Porch	Screened Porch	Roof Overhang	Metal Flashing	Grills of Masonry	Closed Eaves	Shutters	Exterior Screen System	Solar Panels
1	Alvar Street	Cottage			X			X																					X							X			X						X		X								
2	Alvar Street	Cottage			X			X																					X							X			X					X			X								
3	Independence St	Cottage				X		X																					X					X					X						X			X							
4	Independence St	Cottage			X			X										X											X							X					X				X		X								
5	Congress St	Shotgun			X			X																					X					X				X			X														
6	Congress St				X	X		X				X																	X					X							X						X								
7	Desire	Farmhouse					X	X	X																				X						X			X									X								
8	Desire	Craftsman/Bungalow			X			X																					X		X			X							X			X	X		X								
9	Gallier Street	Mulitfamily			X			X																					X		X				X			X						X			X								
10	Gallier Street	Shotgun			X			X																					X					X							X				X		X								
11	Louisa	Shotgun	X		X			X																					X					X							X			X	X		X								
12	Louisa	Ranch				X		X										X																	X			X																	
13	Clouet Street	Shotgun			X			X																					X					X							X			X			X								
14	Clouet Street	Cottage			X			X																					X					X							X			X			X								
15	Piety Street					X		X																					X							X			X					X	X		X						X		
16	Piety Street	Craftsman/Bungalow			X			X																					X					X								X			X		X								
17	Desire	Cottage				X		X				X																	X					X					X					X			X								
18	Desire	Double Shotgun			X			X																					X					X							X				X		X		X						
19	Congress St	Double Shotgun			X			X																					X					X					X					X	X		X								
20	Congress St	Cottage			X			X																					X					X					X								X								

Neighborhood: Lower Ninth Ward			Roof type					Roofing Systems									
								Shingles			Tile		Metal		Other		
House	Street	House Type	Flat	Shed	Gable	Hip	Gambrel	Asphalt Shingles	Slate	Wood	Clay Shingles	Spanish Barrel Tile	Corrugated	Sheet	Built-Up	Green	Sprayed Polyurethane
1	Tennessee	Modern Shotgun	■										■				
2	Tennessee	Shotgun			■	■		■									
3	Tennessee	Modern Shotgun		■		■							■				
4	Tennessee	Modern Shotgun		■									■				
5	Tennessee	Modern Shotgun			■								■				
6	Tennessee	Modern Shotgun		■									■				
7	Tennessee	Modern Shotgun			■								■				
8	Tennessee	Modern Shotgun	■										■				
9	Tennessee	Shotgun			■			■									
10	Tennessee	Modern Shotgun		■									■				
11	Reynes	Modern Shotgun	■										■				
12	Reynes	Arts and Crafts				■							■				
13	Reynes	Cottage			■	■		■									
14	Tennessee	Modern Shotgun		■									■				
15	Tennessee	Shotgun			■								■				
16	Forstall	Craftsman/Bungalow			■		■	■									
17	Forstall	Modern Shotgun	■										■				
18	Forstall	Shotgun				■		■									
19	Forstall	Shotgun				■		■									
20	Forstall	Modern Shotgun		■									■				

	Exterior Walls															
	Masonry				Metal				Wood				Other			
House	Brick	Pre-Cast Concrete	CMU	Stone	Steel Siding	Aluminum Siding	Shingles	Copper	Shingles/Shakes	Plywood	Vertical Wood	Horizonal Wood	Glass	Stucco	Vinyl Siding	Fiber Board
1																■
2												■				
3																■
4																■
5																■
6																■
7																■
8																■
9												■				
10																■
11																■
12																■
13												■				
14												■				
15																■
16												■				
17																■
18												■				
19						■										
20																■

	Foundation Type				Foundation Material						Hurricane Measures										Sust.	
House	Pier/Stilts	Slab-On-Grade	Crawl Space	Basement	Cast-in-place	CMU	Pressure-Treated Wood	Brick	Stone	Steel	Vents	Gutters	Fence	Porch	Screened Porch	Roof Overhang	Metal Flashing	Grills of Masonry	Closed Eaves	Shutters/Storm Windows	Exterior Screen System	Solar Panels
1	■				■						■			■						■	■	
2	■							■						■						■		
3	■					■								■						■		
4	■				■							■		■						■		
5	■				■									■						■		■
6	■						■							■						■		■
7	■				■									■						■		
8	■				■									■						■		
9	■					■						■		■								
10	■									■				■						■	■	
11	■						■							■						■	■	
12	■						■							■						■		
13	■					■					■	■		■								
14	■						■							■						■		
15	■				■									■						■		
16			■		■						■			■								
17	■				■							■		■						■	■	
18	■					■					■											
19	■					■								■								
20	■				■									■						■	■	

Neighborhood: Holy Cross			Roof type					Roofing Systems									
								Shingles			Tile		Metal		Other		
House	Street	House Type	Flat	Shed	Gable	Hip	Gambrel	Asphalt Shingles	Slate	Wood	Clay Shingles	Spanish Barrel Tile	Corrugated	Sheet	Built-Up	Green	Sprayed Polyurethane
1	Reynes	Cottage				■		■				■					
2	Reynes	Cottage			■			■				■					
3	Burgundy St	Craftsman Shotgun			■			■									
4	Burgundy St	Craftsman			■			■				■					
5	Dauphine	Double Shotgun			■				■			■					
6	Dauphine				■			■									
7	Royal	Shotgun			■			■				■					
8	Royal	Shotgun			■			■				■					
9	Chantres	Cottage				■		■				■					
10	Chantres	Cottage			■			■									
11	Flood Street	Florida				■		■									
12	Flood Street	Plantation			■								■				
13	Andry Street	Modern Shotgun		■									■				
14	Andry Street	Ranch			■			■									
15	Douglass	Victorian				■		■									
16	Douglass	Bungalow				■		■				■					
17	Douglass	Bungalow			■			■				■					
18	Douglass	Cottage				■		■				■					
19	Royal	Double Shotgun					■	■									
20	Green	Craftsman/Bungalow			■			■									

	Exterior Walls															
	Masonry				Metal				Wood				Other			
House	Brick	Pre-Cast Concrete	CMU	Stone	Steel Siding	Aluminum Siding	Shingles	Copper	Shingles/Shakes	Plywood	Vertical Wood	Horizonal Wood	Glass	Stucco	Vinyl Siding	Fiber Board
1	■															
2												■				
3	■											■				
4												■				
5												■				
6															■	
7												■				
8												■				
9												■				
10														■		
11												■				
12									■							
13		■									■	■				
14	■															
15	■											■				
16									■							
17												■				
18	■															
19												■				
20												■				

	Foundation Type				Foundation Material						Hurricane Measures										Sust.	
House	Pier/Stilts	Slab-On-Grade	Crawl Space	Basement	Cast-in-place	CMU	Pressure-Treated Wood	Brick	Stone		Vents	Gutters	Fence	Porch	Screened Porch	Roof Overhang	Metal Flashing	Grills of Masonry	Closed Eaves	Shutters	Exterior Screen System	Solar Panels
1			■		■						■	■		■								
2	■				■									■								
3	■							■			■			■								
4	■							■														
5	■					■					■	■										
6			■					■			■	■										
7	■					■					■	■		■								
8	■					■					■	■										
9	■					■					■	■								■		
10		■			■										■							
11	■					■					■											
12	■							■												■		
13	■				■									■							■	
14		■			■							■								■		
15														■								
16	■					■						■		■								
17	■					■					■					■						
18			■					■			■	■		■								
19	■					■					■			■		■						
20	■								■			■		■								

APPENDIX G
SUSTAINABILITY INDEX

Sustainable Index			Roof type					Roofing Systems										Exterior Walls																Foundation Type				Foundation Material						Hurricane Measures										Sust.	
								Shingles			Tile		Metal		Other			Masonry				Metal				Wood				Other																									
System	Credit	Description	Flat	Shed	Gable	Hip	Gambrel	Asphalt Shingles	Slate	Wood	Clay Shingles	Spanish Barrel Tile	Corrugated	Sheet	Built-Up	Green	Sprayed Polyurethane	Brick	Pre-Cast Concrete	CMU	Stone	Steel Siding	Aluminum Siding	Shingles	Copper	Shingles/Shakes	Plywood	Vertical Wood	Horizonal Wood	Glass	Stucco	Vinyl Siding	Fiber Board	Pier/Stilts	Slab-On-Grade	Crawl Space	Basement	Cast-in-place	CMU	Pressure-Treated Wood	Brick	Stone	Steel	Vents	Gutters	Fence	Porch	Screened Porch	Roof Overhang	Metal Flashing	Grills of Masonry	Closed Eaves	Shutters	Exterior Screen System	Solar Panels
LEED	SS Credit 3	Reduce Local Heat Island Effect																																																						
	SS Credit 4.3	Management of Runoff from Roof																																																						
	SS Credit 5	Pest Control Alternatives																																																						
	EA Credit 1	Optimize Energy Performance																																																						
	MR Credit 1.5	Off-site Fabrication																																																						
	MR Prerequisite 2.1	FSC Certified Tropical Wood																																																						
	MR Credit 2.2	Environmentally Preferable Products																																																						
LEED Totals			1	1	1	1	1	2	2	3	2	2	2	2	2	3	2	3	4	3	3	4	3	3	3	3	3	3	3	3	3	3	4	2	1	2	3	2	2	3	2	2	3	0	0	1	0	0	0	0	0	0	0	1	1
Green Globes	Project Management	Environmental Purchasing																																																						
	Site	Minimization of Ecological Impact																																																						
	Site	Enhancement of Watershed Features																																																						
	Energy	Building Envelope																																																						
	Energy	Renewable Sources of Energy																																																						
	Resources	Systems and Materials with Low Environmental Impact																																																						
	Resources	Materials that Minimize Consumption of Resources																																																						
	Resources	Reuse of Existing Building																																																						
	Resources	Building Durability, Adaptability and Disassembly																																																						
	Indoor Environment	Acoustic Comfort																																																						
Green Globes Totals			2	1	1	1	1	3	6	4	6	6	7	7	3	5	4	7	7	7	6	7	7	7	7	5	5	5	5	6	4	4	6	0	0	0	0	4	4	2	2	3	4	0	0	0	0	0	0	0	0	0	0	0	1
FGBC	Energy	HERS Index-Energy Rating																																																						
	Energy	Design, Finishes, Amenities																																																						
	Site	Drainage/Retention																																																						
	Health	Moisture Control																																																						
	Health	Source Control																																																						
	Materials	Components																																																						
	Materials	Waste Reduction																																																						
	Materials	Durability																																																						
	Disaster Mitigation	Hurricane (Wind, Rain, Storm Surge)																																																						
	Disaster Mitigation	Flood																																																						
	Disaster Mitigation	Fire																																																						
	Disaster Mitigation	Termites																																																						
FGBC Totals			3	5	5	5	5	3	4	5	4	4	4	4	2	2	2	5	5	6	5	5	6	5	5	7	7	7	7	5	5	6	6	3	2	3	3	1	1	3	1	1	1	1	0	3	1	1	1	0	1	0	0	3	1
Material Totals			**6**	**7**	**7**	**7**	**7**	**8**	**12**	**12**	**12**	**12**	**13**	**13**	**7**	**10**	**8**	**15**	**16**	**16**	**14**	**16**	**16**	**15**	**15**	**15**	**15**	**15**	**15**	**14**	**12**	**13**	**16**	**5**	**3**	**5**	**6**	**7**	**7**	**8**	**5**	**6**	**8**	**1**	**0**	**4**	**1**	**1**	**1**	**0**	**1**	**0**	**0**	**4**	**3**

APPENDIX H
LIFE CYCLE COSTS

Life Cycle Cost: Roofing	First Cost ($)	Maintenance		Energy		Repairs			Replacements					Total Maintenance & Repair	Life Cycle Costs
Material		Annual Maintenance ($ per year)	**Present Value**	Value of Energy Produce	**Present Value**	Repair Cost	Year	**Present Value**	First Replacement Cost	Year	Second Replacement Cost	Year	**Total in Present Value**	Maintenance/Repair	
Asphalt	**$ 2,513.19**	$ 181.14	**$ 4,938.26**						$ 2,513.19	23	$ 2,513.19	46	**$ 2,099.65**	$ 7,037.91	**$ 9,551.10**
Slate	**$ 7,518.00**	$ 150.00	**$ 4,089.31**			$ 1,127.70	30	**$ 507.08**						$ 4,596.40	**$ 12,114.40**
Clay Tile	**$ 7,913.61**	$ 150.00	**$ 4,089.31**			$ 1,187.04	15	**$ 795.99**						$ 4,885.31	**$ 12,798.92**
Mission Tile	**$ 11,554.89**	$ 150.00	**$ 4,089.31**			$ 1,733.23	15	**$ 1,162.25**						$ 5,251.56	**$ 16,806.45**
Corrugated Metal	**$ 4,521.61**	$ 153.96	**$ 4,197.27**					**$ -**	$ 4,521.61	40	$ 4,521.61	40	**$ 1,557.67**	$ 5,754.94	**$ 10,276.55**
Additional Information:	Discount Rate		**2.70%**			N=	**50**								

Life Cycle Cost: Exterior Walls	First Cost ($)	Maintenance		Energy		Repairs			Replacements			Total Maintenance & Repair	Life Cycle Costs
Material		Annual Maintenance ($ per year)	**Present Value**	Value of Energy Produced	**Present Value**	Repair Cost	Year	**Present Value**	Replacement Cost	Year	**Present Value**	Maintenance/Repair	
Brick	**$ 14,373.61**	$ 100.11	**$ 2,729.21**								**$ -**	$ 2,729.21	**$ 17,102.82**
Stone	**$ 32,662.27**	$ 100.00	**$ 2,726.21**									$ 2,726.21	**$ 35,388.48**
Pre-Cast Concrete	**$ 44,122.00**		**$ -**									$ -	**$ 44,122.00**
Aluminum Siding	**$ 10,369.02**	$ 42.90	**$ 1,169.54**						$ 10,369.02	40	**$ 3,572.07**	$ 4,741.61	**$ 15,110.63**
Shingles/Shakes	**$ 6,792.67**	$ 181.43	**$ 4,946.16**						$ 6,792.67	35	**$ 2,673.47**	$ 7,619.63	**$ 14,412.30**
Vertical Board	**$ 9,266.40**	$ 89.23	**$ 2,432.60**									$ 2,432.60	**$ 11,699.00**
Horizontal Board	**$ 9,266.40**	$ 89.23	**$ 2,432.60**									$ 2,432.60	**$ 11,699.00**
Stucco	**$ 22,946.86**											$ -	**$ 22,946.86**
Vinyl Siding	**$ 3,160.30**											$ -	**$ 3,160.30**
Fiber Board	**$ 6,091.80**	$ 143.00	**$ 3,898.48**									$ 3,898.48	**$ 9,990.28**
Additional Information:	Discount Rate		**2.70%**			N=	**50**						

Life Cycle Cost: Foundations	First Cost ($)	Maintenance		Energy		Repairs			Replacements			Total Maintenance & Repair	Life Cycle Costs
Material		Annual Maintenance ($ per year)	**Present Value**	Value of Energy Produce	**Present Value**	Repair Cost	Year	**Present Value**	Replacement Cost	Year	**Present Value**	Maintenance/Repair	
Piers- Cast in place	**$ 9,574.49**	$ -	**$ -**									$ -	**$ 9,574.49**
Piers CMU	**$ 6,716.37**	$ 15.80	**$ 430.74**									$ 430.74	**$ 7,147.11**
Piers Wood	**$ 8,616.96**	$ 10.40	**$ 283.53**						$ 8,616.96	30	**$ 3,874.72**	$ 4,158.25	**$ 12,775.21**
Piers Brick	**$ 11,653.17**	$ 15.80	**$ 430.74**									$ 430.74	**$ 12,083.91**
Piers Stone	**$ 9,570.42**	$ 15.80	**$ 430.74**									$ 430.74	**$ 10,001.16**
Piers Steel	**$ 19,066.08**	$ -	**$ -**			$ 1,100.00	35	**$432.94**				$ 432.94	**$ 19,499.02**
Slab on Grade	**$ 9,694.12**	$ -	**$ -**									$ -	**$ 9,694.12**
Crawl- Cast in Place	**$ 24,229.37**	$ -	**$ -**									$ -	**$ 24,229.37**
Crawl- CMU	**$ 11,803.46**	$ 14.98	**$ 408.39**									$ 408.39	**$ 12,211.85**
Crawl- Wood	**$ 8,616.96**	$ 10.40	**$ 283.53**						$ 8,616.96	30	**$ 3,874.72**	$ 4,158.25	**$ 12,775.21**
Crawl- Brick	**$ 12,359.89**	$ 14.98	**$ 408.39**									$ 408.39	**$ 12,768.28**
Crawl- Stone	**$ 16,464.22**	$ 14.98	**$ 408.39**									$ 408.39	**$ 16,872.61**
Basement- CMU	**$ 17,952.67**	$ 29.95	**$ 816.50**									$ 816.50	**$ 18,769.17**
Basement- Brick	**$ 18,953.49**	$ 29.95	**$ 816.50**									$ 816.50	**$ 19,769.99**
Additional Information:	Discount Rate		**2.70%**			N=	**50**						

APPENDIX I
QUALITY MODELS

Roofing Systems		Costruction Factors		Costs		Structural Permanance			Local Environment	
Material Category	**Material**	**Schedule**	**Labor Intensity**	**Initial Cost**	**Life Cycle Cost**	**Durability**	**Maintenance**	**Hurricane Resistance**	**Sustainability**	**Historical Vernacular**
Shingles	**Asphalt Shingles**	4 days	43%	$2,513.19	$9,551.10	23	$7,037.91	Average	8	Average
	Slate	7 days	23%	$7,518.00	$12,114.40	100	$4,596.40	Above Average	12	Average
Tile	**Clay**	7 days	23%	$7,913.61	$12,798.92	100	$4,885.31	Above Average	12	Above Average
	Spanish Barrel Tile	10 days	23%	$11,554.89	$16,806.45	100	$5,251.56	Above Average	12	Excellent
Metal	**Corrugated metal**	1 day	26%	$4,521.61	$10,276.55	40	$5,754.94	Excellent	13	Below Average

Parwise Comparison Matrix		Costruction Factors		Costs		Structural Permanance			Local Environment		
		Schedule	**Labor Intensity**	**Initial Cost**	**Life Cycle Cost**	**Durability**	**Maintenance**	**Hurricane Resistance**	**Sustainability**	**Historical Vernacular**	**Totals**
Construction Factors	**Schedule**		1	0	0	0	1	0	0	0	2
	Labor Intensity	0		0	0	0	0	0	0	0	1
Costs	**Initial Cost**	2	3		0	1	2	0	1	1	10
	Life Cycle Cost	3	4	1		0	3	1	2	1	15
Structural Permanance	**Durability**	2	3	1	0		2	0	1	1	10
	Maintenance	1	1	0	0	0		0	0	0	2
	Hurricane Resistance	3	4	1	1	0	3		2	1	15
Local Environment	**Sustainability**	1	2	0	0	0	1	0		0	4
	Historical Vernacular	2	3	1	0	1	2	0	1		10
	Weight	2	1	10	15	10	2	15	4	10	

Five Point Likert Scale Scores		Costruction Factors		Costs		Structural Permanance			Local Environment	
Material Category	**Material**	**Schedule**	**Labor Intensity**	**Initial Cost**	**Life Cycle Cost**	**Durability**	**Maintenance**	**Hurricane Resistance**	**Sustainability**	**Historical Vernacular**
Shingles	**Asphalt Shingles**	4	1	5	5	2	1	3	1	3
	Slate	2	5	3	4	5	5	4	4	3
Tile	**Clay**	2	5	3	3	5	4	4	4	4
	Spanish Barrel Tile	1	5	1	1	5	4	4	4	5
Metal	**Corrugated metal**	5	4	4	5	3	3	5	5	2

Likert Scale Scores x Parwise Comparison		Costruction Factors		Costs		Structural Permanance			Local Environment		
Material Category	**Material**	**Schedule**	**Labor Intensity**	**Initial Cost**	**Life Cycle Cost**	**Durability**	**Maintenance**	**Hurricane Resistance**	**Sustainability**	**Historical Vernacular**	**Totals**
Shingles	**Asphalt Shingles**	8	1	50	75	20	2	45	4	30	235
	Slate	4	5	30	60	50	10	60	16	30	265
Tile	**Clay**	4	5	30	45	50	8	60	16	40	258
	Spanish Barrel Tile	2	5	10	15	50	8	60	16	50	216
Metal	**Corrugated metal**	10	4	40	75	30	6	75	20	20	280

1	2	3	4	5
		Schedule		
9-10 days	*7-8 days*	*5-6 days*	*3-4 days*	*1-2 days*

1	2	3	4	5
		Labor Intensity		
43%	*38%*	*33%*	*28%*	*23%*

1	2	3	4	5
		Initial Cost		
$11,500	*$9,250*	*$7,000*	*$4,750*	*$2,500*

1	2	3	4	5
		Life Cycle Cost		
$17,000	*$15,125*	*$13,250*	*$11,375*	*$9,500*

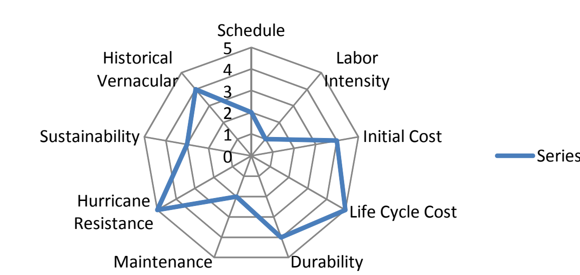
1	2	3	4	5
		Durability		
0 years	*25 years*	*50 years*	*75 years*	*100 years*

1	2	3	4	5
		Maintenance		
$7,000	*$6,375*	*$5,750*	*$5,125*	*$4,500*

1	2	3	4	5
		Hurricane Resistance		
Poor	*Below Average*	*Average*	*Above Average*	*Excellent*

1	2	3	4	5
		Sustainability		
8-9 points	*10 points*	*11 points*	*12 points*	*13 points*

1	2	3	4	5
		Historical Vernacular		
Poor	*Below Average*	*Average*	*Above Average*	*Excellent*



Exterior Wall Systems		Costruction Factors		Costs		Structural Permanance			Local Environment	
Material Category	Material	Schedule	Labor Intensity	Initial Cost	Life Cycle Cost	Durability	Maintenance	Hurricane Resistance	Sustainability	Historical Vernacular
Masonry	**Brick**	7 days	64%	$14,373.61	$17,102.82	100	$2,729.21	Above Average	15	Above Average
	Pre-Cast Concrete	5 days	32%	$44,122.00	$44,122.00	50	$0.00	Excellenct	16	Below Average
	Stone	12 days	50%	$32,662.27	$35,388.48	100	$2,726.21	Above Average	14	Below Average
Metal	**Aluminum Siding**	5 days	40%	$10,369.02	$15,110.63	40	$4,741.61	Below Average	15	Average
Wood	**Shingles/Shakes**	9 days	48%	$6,792.67	$14,412.30	35	$7,619.63	Average	15	Below Average
	Vertical Boards	7 days	26%	$9,266.40	$11,699.00	50	$2,432.60	Average	15	Average
	Horizontal Boards	7 days	26%	$9,266.40	$11,699.00	50	$2,432.60	Average	15	Excellent
Other	**Stucco**	3 days	75%	$16,719.86	$16,719.86	Lifetime	$0.00	Above Average	12	Below Average
	Vinyl Siding	3 days	58%	$3,160.30	$3,160.30	50	$0.00	Poor	13	Average
	Fiber Board	3 days	56%	$6,091.80	$9,990.28	50	$3,898.48	Above Average	16	Above Average

Parwise Comparison Matrix		Costruction Factors		Costs		Structural Permanance			Local Environment		
		Schedule	Labor Intensity	Initial Cost	Life Cycle Cost	Durability	Maintenance	Hurricane Resistance	Sustainability	Historical Vernacular	Totals
Construction Factors	**Schedule**		1	0	0	0	1	0	0	0	2
	Labor Intensity	0		0	0	0	0	0	0	0	1
Costs	**Initial Cost**	2	3		0	1	2	0	1	1	10
	Life Cycle Cost	3	4	1		0	3	1	2	1	15
Structural Permanance	**Durability**	2	3	1	0		2	0	1	1	10
	Maintenance	1	1	0	0	0		0	0	0	2
	Hurricane Resistance	3	4	1	1	0	3		2	1	15
Local Environment	**Sustainability**	1	2	0	0	0	1	0		0	4
	Historical Vernacular	2	3	1	0	1	2	0	1		10
	Weight	2	1	10	15	10	2	15	4	10	

Five Point Likert Scale Scores		Costruction Factors		Costs		Structural Permanance			Local Environment	
Material Category	Material	Schedule	Labor Intensity	Initial Cost	Life Cycle Cost	Durability	Maintenance	Hurricane Resistance	Sustainability	Historical Vernacular
Masonry	**Brick**	3	2	4	4	4	4	4	4	4
	Pre-Cast Concrete	4	4	1	1	2	5	5	5	2
	Stone	1	3	2	2	4	4	4	3	2
Metal	**Aluminum Siding**	4	4	4	4	2	2	2	5	3
Wood	**Shingles/Shakes**	2	3	5	4	1	1	3	4	2
	Vertical Boards	3	5	4	4	2	4	3	4	3
	Horizontal Boards	3	5	4	4	2	4	3	4	5
Other	**Stucco**	5	1	3	3	5	5	4	1	2
	Vinyl Siding	5	2	5	5	2	5	1	2	3
	Fiber Board	5	3	5	4	2	3	4	5	4

Likert Scale Scores x Parwise Comparison		Costruction Factors		Costs		Structural Permanance			Local Environment		
Material Category	Material	Schedule	Labor Intensity	Initial Cost	Life Cycle Cost	Durability	Maintenance	Hurricane Resistance	Sustainability	Historical Vernacular	Totals
Masonry	**Brick**	6	2	40	60	40	8	60	16	40	272
	Pre-Cast Concrete	8	4	10	15	20	10	75	20	20	182
	Stone	2	3	20	30	40	8	60	12	20	195
Metal	**Aluminum Siding**	8	4	40	60	20	4	30	20	30	216
Wood	**Shingles/Shakes**	4	3	50	60	10	2	45	16	20	210
	Vertical Boards	6	5	40	60	20	8	45	16	30	230
	Horizontal Boards	6	5	40	60	20	8	45	16	50	250
Other	**Stucco**	10	1	30	45	50	10	60	4	20	230
	Vinyl Siding	10	2	50	75	20	10	15	8	30	220
	Fiber Board	10	3	50	60	20	6	60	20	40	269

1	2	3	4	5
Schedule				
11-12 days	*9-10 days*	*7-8 days*	*5-6 days*	*3-4 days*

1	2	3	4	5
Labor Intensity				
75%	*63%*	*50%*	*38%*	*25%*

1	2	3	4	5
Initial Cost				
$44,000	*$33,750*	*$23,500*	*$13,250*	*$3,000*

1	2	3	4	5
Life Cycle Cost				
$44,000	*$33,750*	*$23,500*	*$13,250*	*$3,000*

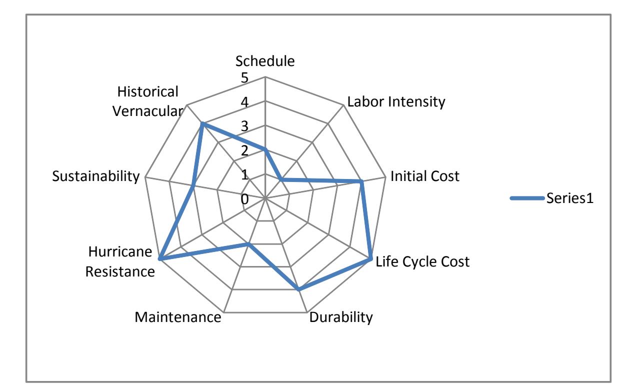
1	2	3	4	5
Durability				
25 years	*50 years*	*75years*	*100 years*	*Lifetime*

1	2	3	4	5
Maintenance				
$7,500	*$5,625*	*$3,750*	*$1,875*	*$0*

1	2	3	4	5
Hurricane Resistance				
Poor	*Below Average*	*Average*	*Above Average*	*Excellent*

1	2	3	4	5
Sustainability				
12 points	*13 points*	*14 points*	*15 points*	*16 points*

1	2	3	4	5
Historical Vernacular				
Poor	*Below Average*	*Average*	*Above Average*	*Excellent*



Foundation Systems		Costruction Factors		Costs		Structural Permanance			Local Environment	
Material Category	Material	Schedule	Labor Intensity	Initial Cost	Life Cycle Cost	Durability	Maintenance	Hurricane Resistance	Sustainability	Historical Vernacular
Piers/Stilts	**Cast-In-Place**	1 day	9%	$9,574.49	$9,574.49	200	$0.00	Above Average	11	Above Average
	Concrete Masonry Unit	2 days	48%	$6,716.37	$7,147.11	100	$430.74	Above Average	11	Average
	Pressure-Treated Wood	2 days	27%	$8,616.96	$12,775.21	30	$4,158.25	Average	12	Average
	Brick	6 days	49%	$11,653.17	$12,083.91	100	$430.74	Above Average	9	Above Average
	Stone	6 days	49%	$9,570.42	$10,001.16	100	$430.74	Above Average	10	Below Average
	Steel	2 days	16%	$19,066.08	$19,499.02	100	$432.94	Excellent	12	Below Average
Slab-on-Grade	**Cast-In-Place**	1 day	24%	$9,694.12	$9,694.12	200	$0.00	Poor	9	Above Average
Crawl Space	**Cast-In-Place**	2 days	45%	$24,229.37	$24,229.37	200	$0.00	Above Average	11	Excellent
	Concrete Masonry Unit	6 days	41%	$11,803.46	$12,211.85	100	$408.39	Above Average	11	Average
	Pressure-Treated Wood	2 days	27%	$8,616.96	$12,775.21	30	$4,158.25	Average	12	Average
	Brick	4 days	51%	$13,159.89	$13,568.28	100	$408.39	Above Average	9	Above Average
	Stone	8 days	47%	$16,464.22	$16,872.61	100	$408.39	Above Average	10	Average
Basement	**Concrete Masonry Unit**	4 days	40%	$17,952.67	$18,769.17	100	$816.50	Excellent	12	Below Average
	Brick	7 days	52%	$18,953.49	$19,769.99	100	$816.50	Excellent	10	Below Average

1	2	3	4	5
		Schedule		
9-10 days	*7-8 days*	*5-6 days*	*3-4 days*	*1-2 days*

1	2	3	4	5
		Labor Intensity		
52%	*41%*	*31%*	*20%*	*9%*

1	2	3	4	5
		Initial Cost		
$24,000	*$19,500*	*$15,000*	*$10,500*	*$6,000*

1	2	3	4	5
		Life Cycle Cost		
$24,000	*$19,500*	*$15,000*	*$10,500*	*$6,000*

1	2	3	4	5
		Durability		
0 years	*50 years*	*100 years*	*150 years*	*200 years*

Parwise Comparison Matrix		Costruction Factors		Costs		Structural Permanance			Local Environment		
		Schedule	Labor Intensity	Initial Cost	Life Cycle Cost	Durability	Maintenance	Hurricane Resistance	Sustainability	Historical Vernacular	Totals
Construction Factors	**Schedule**		1	0	0	0	1	0	0	0	2
	Labor Intensity	0		0	0	0	0	0	0	0	1
Costs	**Initial Cost**	2	3		0	1	2	0	1	1	10
	Life Cycle Cost	3	4	1		0	3	1	2	1	15
Structural Permanance	**Durability**	2	3	1	0		2	0	1	1	10
	Maintenance	1	1	0	0	0		0	0	0	2
	Hurricane Resistance	3	4	1	1	0	3		2	1	15
Local Environment	**Sustainability**	1	2	0	0	0	1	0		0	4
	Historical Vernacular	2	3	1	0	1	2	0	1		10
	Weight	2	1	10	15	10	2	15	4	10	

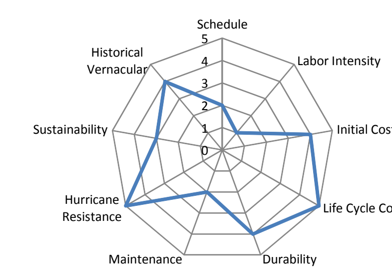
1	2	3	4	5
		Maintenance		
$4,000	*$3,000*	*$2,000*	*$1,000*	*$0*

1	2	3	4	5
		Hurricane Resistance		
Poor	*Below Average*	*Average*	*Above Average*	*Excellent*

1	2	3	4	5
		Sustainability		
8 points	*9 points*	*10 points*	*11 points*	*12 points*

1	2	3	4	5
		Historical Vernacular		
Poor	*Below Average*	*Average*	*Above Average*	*Excellent*

Five Point Likert Scale Scores		Costruction Factors		Costs		Structural Permanance			Local Environment	
Material Category	Material	Schedule	Labor Intensity	Initial Cost	Life Cycle Cost	Durability	Maintenance	Hurricane Resistance	Sustainability	Historical Vernacular
Piers/Stilts	**Cast-In-Place**	5	5	4	4	5	5	4	4	4
	Concrete Masonry Unit	5	1	5	5	3	5	4	4	3
	Pressure-Treated Wood	5	3	4	3	2	1	3	5	3
	Brick	3	1	4	4	3	5	4	2	4
	Stone	3	1	4	4	3	5	4	3	2
	Steel	5	4	2	2	3	5	5	5	2
Slab-on-Grade	**Cast-In-Place**	5	4	4	4	5	5	1	2	4
Crawl Space	**Cast-In-Place**	5	2	1	1	5	5	4	4	5
	Concrete Masonry Unit	3	2	4	4	3	5	4	4	3
	Pressure-Treated Wood	5	3	4	3	2	1	3	5	3
	Brick	4	1	3	3	3	5	4	2	4
	Stone	2	1	3	3	3	5	4	3	3
Basement	**Concrete Masonry Unit**	4	2	2	2	3	4	5	5	2
	Brick	2	1	2	2	3	4	5	3	2



Likert Scale Scores x Parwise Comparison		Costruction Factors		Costs		Structural Permanance			Local Environment		
Material Category	Material	Schedule	Labor Intensity	Initial Cost	Life Cycle Cost	Durability	Maintenance	Hurricane Resistance	Sustainability	Historical Vernacular	Totals
Piers/Stilts	**Cast-In-Place**	10	5	40	60	50	10	60	16	40	**291**
	Concrete Masonry Unit	10	1	50	75	30	10	60	16	30	**282**
	Pressure-Treated Wood	10	3	40	45	20	2	45	20	30	**215**
	Brick	6	1	40	60	30	10	60	8	40	**255**
	Stone	6	1	40	60	30	10	60	12	20	**239**
	Steel	10	4	20	30	30	10	75	20	20	**219**
Slab-on-Grade	**Cast-In-Place**	10	4	40	60	50	10	15	8	40	**237**
Crawl Space	**Cast-In-Place**	10	2	10	15	50	10	60	16	50	**223**
	Concrete Masonry Unit	6	2	40	60	30	10	60	16	30	**254**
	Pressure-Treated Wood	10	3	40	45	20	2	45	20	30	**215**
	Brick	8	1	30	45	30	10	60	8	40	**232**
	Stone	4	1	30	45	30	10	60	12	30	**222**
Basement	**Concrete Masonry Unit**	8	2	20	30	30	8	75	20	20	**213**
	Brick	4	1	20	30	30	8	75	12	20	**200**

LIST OF REFERENCES

Anonymous (2011). "Geographic Information System GIS: Introduction." http://www.ccdmd.qc.ca/en/gis/before.html (10/05, 2011).

Anonymous (2011). "Richter Scale Magnitude." http://en.wikipedia.org/wiki/Richter_magnitude_scale (06/27, 2011).

Anonymous (2009). "Home Features and Materials-Make It Right." http://www.makeitrightnola.org/index.php/building_green/detail/materials/ (10/03, 2011).

Anonymous (2009). "Make It Right." http://www.makeitrightnola.org (10/03, 2011).

Anonymous (2008). "1000 Days Later." *Popular Mechanics,* 185(9), 91-100.

Anonymous (2001). "States Adopt Building Codes to Make Homes Safer." *State Legis.,* 27(9), 7.

Advisory Council on Historic Preservation. (2009). "The National Historic Preservation Program." http://www.achp.gov/nhpp.html (09/28, 2011).

Baldwin, A., Poon, C., Shen, L., Austin, S., and Wong, I. (2009). "Designing out waste in high-rise residential buildings: Analysis of precasting methods and traditional construction." *Renewable Energy: An International Journal,* 34(9), 2067-2073.

Barnett, J., and and Beckman, J. (2006). "Reconstructing New Orleans: A Progress Report." *Rebuilding Urban Places After Disasters: Lessons from Hurricane Katrina,* E. Birch, and S. and Wachter, eds., University of Pennsylvania Press, Philadelphia, PA, 288-304.

Bergeron, A., and Sawyer, T. (2006). "Louisiana passes new statewide building code; critics say it may burden home repairs." *Archit.Rec.,* 194(1), 34-34.

Berns, M., Townend, A., Khayat, Z., Balagopal, B., Reeves, M., Hopkins, M., and Kruschwitz, N. (2009). "Sustainability and Competitive Advantage." *MIT Sloan Management Review,* 51(1), 19-26.

Blas, L. "Pitt tours New Orleans homes." *USA Today,* .

Bolin, R. (1998). *The Northridge earthquake: Vulnerability and disaster.* Routledge, London.

Bradford, N. M., and Sen, R. (2004). "Gable-End Wall Stability in Florida Hurricane Regions, 10-Year Review: Post-Hurricane Andrew (1992) to Florida Building Code (2002)." *J.Archit.Eng.,* 10(2), 45-52.

Chastain, B., Sawyer, T., Rubin, D., Powers, M., and Armistead, T. (2004). "New Florida Codes Bring Mixed Success." *ENR: Engineering News-Record,* 253(8), 8-9.

Chen, Y., Okudan, G., and Riley, D. R. (2010). "Decision support for construction method selection in concrete buildings: Prefabrication adoption and optimization." *Autom.Constr.,* 19(6), 665-675.

Chittum, R., and Francis, T. (2005). "Building Houses to Stand." *Wall Street Journal - Eastern Edition,* 246(65), B1-B2.

Curtis, A. J., Mills, J. W., and Leitner, M. (2006). "Spatial confidentiality and GIS: re-engineering mortality locations from published maps about Hurricane Katrina." *International Journal of Health Geographics,* 5 44-12.

Department of Public Safety. (2011). "Codes and Standards." http://lsuccc.dps.louisiana.gov/codes.html (10/03, 2011).

DOE. (1997). "Earth-Sheltered Houses." *Energy Efficiency and Renewable Energy Clearinghouse,* February 1-7.

Durieux, L., Lagabrielle, E., and Nelson, A. (2008). "A method for monitoring building construction in urban sprawl areas using object-based analysis of Spot 5 images and existing GIS data." *ISPRS J.Photogramm.Remote Sens.,* 63(4), 399-408.

Edwards, J. D. (2006). "Creole Architecture: A Comparative Analysis of Upper and Lower Louisiana and Saint Domingue." *International Journal of Historical Archaeology,* 10(3), 237-267.

ENR. (2007). "Louisiana Gears Up To Enforce New Statewide Building Code. (Cover story)." *ENR: Engineering News-Record,* 258(17), 24-24.

ENR. (2006). "Concrete Homes Address New Orleans Housing Crisis." *ENR: Engineering News-Record,* 257(10), 14.

FEMA. (2011). "Disaster Information." http://www.fema.gov/hazard/index.shtm (06/27, 2011).

FGBC. (2011). "Organization Background and Facts." http://www.floridagreenbuilding.org/files/1/File/FGBC_Organizational_Fact_Sheet2011.pdf (10/3, 2011).

Finch, C., Emrich, C., and Cutter, S. (2010). "Disaster disparities and differential recovery in New Orleans." *Population & Environment,* 31(4), 179-202.

Global Green. (2011). "Holy Cross Project." http://globalgreen.org/neworleans/holycross/about/ (10/03, 2011).

Global Green. (2011). "Rebuilding New Orleans." http://www.globalgreen.org/neworleans/ (10/03, 2011).

Gopalakrishnan, C., and Okada, N. (2007). "Designing new institutions for implementing integrated disaster risk management: key elements and future directions." *Disasters,* 31(4), 353-372.

Gordon, S. H. (2007). "New Orleans musicians get sound new housing." *Archit.Rec.,* 195(6), 24-24.

Greater New Orleans Community Data Center. (2003). "Parish Data and Info." http://www.gnocdc.org/orleans/index.html (10/14, 2011).

Green Building Institute. (2011). "Green Globes Frequently Asked Questions." http://www.greenglobes.com/about-faq.asp (10/13, 2011).

Green Building Institute. (2011). "What is Green Globes?" http://www.greenglobes.com/about.asp (10/13, 2011).

Green Building Institute. (2011). "Why Green Globes is Better?" http://www.greenglobes.com/about-why.asp (10/13, 2011).

Guikema, S. D. (2009). "Infrastructure Design Issues in Disaster-Prone Regions." *Science,* 323(5919), 1302-1303.

Habitat for Humanity. (2011). "About Disaster Response." http://www.habitat.org/disaster/about/default.aspx (10/06, 2011).

Habitat for Humanity. (2011). "Habitat for Humanity's Disaster Response." http://www.habitat.org/disaster/default.aspx (10/06, 2011).

Hadhazy, A., (2011). "Extreme Building Codes: Protect Your Home from Natural Disasters." http://www.popularmechanics.com/home/improvement/outdoor-projects/extreme-building-codes?src=soc_em (06/27, 2011).

Hashemi, M., and Alesheikh, A. A. (2011). "A GIS-based earthquake damage assessment and settlement methodology." *Soil Dynamics & Earthquake Engineering,* 31(11), 1607-1617.

Holbein, A. (2009). "Building a Recovery Department." *Planning,* 75(2), 36-39.

Kennedy, S. (2011). "Update make it Right." *Archit.Rec.,* 199(5), 46-46.

Kibert, C., Zimmir, J., and Guy, G. (2002). *Construction Ecology: Nature as the Basis for Green Buildings.* Spon Press, New York, NY.

Kingsley, K. (2007). "New Orleans Architecture: Building Renewal." *Journal of American History,* 94(3), 716-725.

Kirk, S. J. (1994). "Quality Modeling: Defining Project Expectations." *International Conference of the Society of American Value Engineers,* .

Kopec, D. (2006). *Environmental Psychology for Design.* Fairfield Publications, Inc., New York, NY.

Krupa, M. (2008). "City's Demolition Review Panel Back in Business." *The Times-Picayune (New Orleans),* B1.

Kunreuther, H. (2008). "Reducing Losses from Catastrophic Risks through Long-Term Insurance and Mitigation." *Social Research,* 75(3), 905-930.

Kunreuther, H. (1998). "Introduction." *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States,* H. Kunreuther, and R. J. Roth, eds., Joseph Henry Press, Washington, D.C., 1-16.

Levine, J. N., Esnard, A., and Sapat, A. (2007). "Population Displacement and Housing Dilemmas Due to Catastrophic Disasters." *Journal of Planning Literature,* 22(1), 3-15.

Lin, G., Shen, G. Q., Sun, M., and Kelly, J. (2011). "Identification of Key Performance Indicators for Measuring the Performance of Value Management Studies in Construction." *Journal of Construction Engineering & Management,* 137(9), 698-706.

Lin, G., and Shen, Q. (2007). "Measuring the Performance of Value Management Studies in Construction: Critical Review." *J.Manage.Eng.,* 23(1), 2-9.

Lindt, V. D., Graettinger, A., Gupta, R., Skaggs, T., Pryor, S., and Fridley, K. J. (2007). "Performance of Wood-Frame Structures during Hurricane Katrina." *J.Perform.Constr.Facil.,* 21(2), 108-116.

Link, L. E. (2010). "The anatomy of a disaster, an overview of Hurricane Katrina and New Orleans." *Ocean Eng.,* 37(1), 4-12.

Lubell, S. (2005). "Louisiana conference sets priorities for rebuilding." *Archit.Rec.,* 193(12), 29-30.

Luegenbiehl, H. C. (2007). "Disasters as Object Lessons in Ethics: Hurricane Katrina." *IEEE Technology & Society Magazine,* 26(4), 10-15.

Maantay, J., and and Zeigler, J. (2006). *GIS for the Urban Environment.* Esri Press, Redlands, CA.

Malin, N. (2005). "Green Globes Emerges to Challenge LEED." *EBN,* 14(3),.

Malin, N. (2005). "The Mindset Thing: Exploring the Deeper Potential of Integrated Design." *EBN,* .

Malin, N. (2004). "Integrated Design." *EBN,* 13(11),.

McDonald, R. (2003). *Introduction to Natural and Man-Made Disasters and Their Effects on Buildings.* Architectural Press, Burlington, MA.

Mehta, M., Scarborough, W., and Armpriest, D. (2008). *Building Construction: Principles, Materials and Systems.* Pearson Prentice Hall, Upper Saddle River, NJ.

Merriam-Webster. (2011). "Definition of Disaster." http://www.merriam-webster.com/dictionary/disaster (09/05, 2011).

Miller, W. D., Pollack, C. E., and Williams, D. R. (2011). "Healthy Homes and Communities: Putting the Pieces Together." *Am.J.Prev.Med.,* 40 S48-S57.

Morel, J. C., Mesbah, A., Oggero, M., and Walker, P. (2001). "Building Houses with Local Materials: means to drastically the environmental impact of construciton." *Building and Environment,* 36 1119-1126.

Myers, C., Slack, T., and Singelmann, J. (2008). "Social vulnerability and migration in the wake of disaster: the case of Hurricanes Katrina and Rita." *Population & Environment,* 29(6), 271-291.

NOAA. (2009). "Hurricane Andrew." http://www.ncdc.noaa.gov/oa/satellite/satelliteseye/hurricanes/andrew92/andrew.html (10/03, 2011).

NOAA. (2005). "Hurricane Katrina." http://www.ncdc.noaa.gov/special-reports/katrina.html (09/16, 2011).

Odum, H. T. (2002). "Material Circulation, Energy Hierarchy and Building Construction." *Construction Ecology: Nature as the Basis for Green Buildings,* C. Kibert, J. Zimir, and G. Guy, eds., Spon Press, New York, NY, 37-28.

Oktay, D. (2001). "Design with the Climate in Housing Environments: An Analysis in Northern Cyprus." *Building and Environment,* .

Oliver-Smith, A. (2006). "Disasters and Forced Migration in the 21st Century." *Understanding Katrina: Perspectives from the Social Sciences,* http://understandingkatrina.ssrc.org/oliver-smith.

Olshansky, R. B., Johnson, L. A., Horne, J., and Nee, B. (2008). "Longer View: Planning for the Rebuilding of New Orleans." *Journal of the American Planning Association,* 74(3), 273-287.

Owens, B. (2010). "LEED & Green Building Codes." *ASHRAE J.,* 52(6), S6-S8.

Pasterick, E. (1998). "The National Flood Insurance Program." *Paying the Price: The Status and Role of Insurance Against Natural Disasters in the United States,* H. Kunruther, and R. J. Roth, eds., Joseph Henry Pres, Washington, D.C., 125-154.

Petersen, M., (2011). "Blessed Bounty: Reflections on the Sustainable Design Competition." http://globalgreen.org/blogs/global/?p=1890 (10/03, 2011).

Petterson, J., Stanley, L., Glazier, E., and Philipp, J. (2006). "A Preliminary Assessment of Social and Economic Impacts Associated with Hurricane Katrina." *American Anthropologists,* 108(4), 644-670.

Piepkorn, M. (2005). "The Natural Building Movement." *EBN,* 14(5),.

Queena, S. K. (2004). "Industry Aims To Make Homes Disaster-Proof." *Wall Street Journal - Eastern Edition,* 244(64), D1-D6.

Rebuild Together. (2010). "Rebuild 1000 Statistics." http://www.rebuildingtogether.org/section/initiatives/drr/r1000about/drrstats1 (10/06, 2011).

Rebuild Together. (2008). "About Rebuild 1000." http://www.rebuildingtogether.org/section/initiatives/drr/r1000about (10/06, 2011).

Robichaud, L. B., and Anantatmula, V. S. (2011). "Greening Project Management Practices for Sustainable Construction." *J.Manage.Eng.,* 27(1), 48-57.

Saenz, A. (2011). "New Orleans Population Shrinks By 1/3 In 10 Years." *ABC News,* http://abcnews.go.com/Politics/orleans-population-shrinks-10-years/story?id=12856256.

Sagun, A., Bouchlaghem, D., and Anumba, C. J. (2009). "A scenario-based study on information flow and collaboration patterns in disaster management." *Disasters,* 33(2), 214-238.

Sawyer, T., Korman, R., Post, N., Powers, M., Armistead, T., Rubin, D., and Chastain, B. (2004). "Deadly Hurricane Trio Whips Up New Debate." *ENR: Engineering News-Record,* 253(12), 10-13.

Schawb, J., Topping, K., Eadie, C., Deyle, R., and Smith, R. (1998). *Planning for Post-Disaster Recovery and Reconstruction.* American Planning Association, Chicago, IL.

Scheuer, C., and Keoleian, G. (2002). "Evaluation of LEED using Life Cycle Assessment Methods." *NIST,* 15-21.

Stark, J. (2002). "New Building Code Brings Cost, Confusion." *St. Pete Times,* Home(August 19, 2002),.

Swan, A. J., Rteil, A., and Lovegrove, G. (2011). "Sustainable Earthen and Straw Bale Construction in North American Buildings: Codes and Practice." *J.Mater.Civ.Eng.,* 23(6), 866-872.

Thomson, H. (2010). "How to build a way out of disaster." *New Sci.,* 205(2750), 46-47.

Upton, D. (2006). "Understanding New Orlean's Architectural Ecology." *Rebuilding Urban Places after Disaster: Lessons from Hurricane Katrina,* E. Birch, and S. and Wachter, eds., University of Pennsylvania Press, Philadelphia, PA, 275-287.

USGBC. (2011). "LEED FAQ." http://www.usgbc.org/DisplayPage.aspx?CMSPageID=1819 (10/08, 2011).

USGBC. (2011). "Scope and Eligibility Guidelines: LEED for Homes 2008." www.usgbc.org (10/28, 2011).

Van der Ryn, S., and and Cowan, S. (1996). *Ecological Design.* Island Press, Washington, D.C.

Van der Ryn, S., and and Pena, R. (2002). "Ecologic Analogues and Architecture." *Construction Ecology: Nature as the Basis for Green Buildings,* C. Kibert, J. Zimir, and G. Guy, eds., Spon Press, New York, NY, 231-247.

Verderber, S. (2010). "Five Years After-Three New Orleans Neighborhoods." *Journal of Architectural Education,* 64(1), 107-120.

Wallace, N. (2008). "Katrina's Victims Pull Together to Rebuild a Neighborhood." *Chronicle of Philanthropy,* 20(14), 16-16.

BIOGRAPHICAL SKETCH

Rachel Compton was born and raised in Clearwater, Florida, the eldest of two children. The desire to design developed early, when, at ten-years-old, she announced her plans to transform the local abandoned meat-packing warehouse into a homeless shelter. After successfully graduating valedictorian of her high school class, Rachel earned a Bachelor of Design in Interior Design in 2009 from the University of Florida, summa cum laude.

Immediately following undergraduate graduation, Rachel was accepted and enrolled in the M.E. Rinker Sr. School of Building Construction to begin working on a Master of Science in Building Construction. While there, she was privileged to be a member of the university's 2010 Solar Decathlon Team. Upon graduation, Rachel pursued a career in the fields of interior design and natural disaster reconstruction.