Rebuilding New Orleans With Affordable, Hurricane-Resistant Residential Construction

James Goedert
University of Nebraska–Lincoln

Abstract

This article describes a project in which the overall objective was to provide information and designs for the rebuilding effort in New Orleans following the city's destruction by Hurricane Katrina in August 2005. More than 250,000 houses were damaged in New Orleans—100,000 beyond repair. The University of Nebraska–Lincoln teamed with Catholic Charities of the Archdiocese of New Orleans to work with residents in the Tremé/Lafitte neighborhoods of Orleans Parish to rehabilitate, construct, and reconstruct their homes. Three objectives of the project were to (1) develop a rehabilitation manual; (2) design 10 new affordable house designs with 10 variations, for a total of 20 new designs; and (3) capture the designs of 10 houses to be demolished and rebuilt.

Introduction

Residential housing in the city of New Orleans was severely affected when Hurricane Katrina made a direct hit on the city on August 29, 2005. The devastation of the 100-miles-per-hour winds and torrential rain was dwarfed by the subsequent destruction caused by levee breaks in four locations throughout the city. Todd Richardson, the U.S. Department of Housing and Urban Development's (HUD's) deputy director of Program Evaluations Division, called Hurricane Katrina the most disruptive hurricane recorded in terms of financial damage. Estimates indicate that more than 250,000 houses were damaged in New Orleans,100,000 beyond repair (Angelo and Bergeron, 2007). Nearly 1 year after the hurricane, the population of Orleans Parish had decreased from more than 450,000 to less than half that number (U.S. Census Bureau, 2006). With more than 75 percent of Orleans Parish uninhabitable, an immediate need existed for low-cost permanent housing. Many houses could be rehabilitated, while others required complete rebuilding.

The problem of rebuilding the city was exacerbated by a number of factors, including political pressures from opposing constituencies, the inflated cost of construction, an unskilled workforce, the lack of qualified building inspectors returning to work, and a number of building code issues. Political pressures include the issues regarding various approaches to dealing with some of the worst concentrations of poverty in the country. Before Hurricane Katrina unleashed her destruction, 27.9 percent of Orleans Parish residents lived below the poverty level, according to the U.S. Census Bureau (2000). Cochran (2005) described New Orleans as socially dysfunctional, indicating the need to "rebuild both the infrastructure and the social fabric." Many residents and organizations thought the storm provided the perfect time to eliminate the more blighted areas of New Orleans, especially those neighborhoods close to downtown and the French Quarter, and replace them with new homes attractive to middle- and upper-income families. Others believed that those neighborhoods needed protection to preserve their history and integrity as well as to avoid exploiting the disadvantaged residents who had suffered the most because of this tragedy. Some individuals and groups expressed "concern that gentrification of New Orleans will occur that economically forces its lowest-income residents from the city" (USGBC, 2005: 5).

The demand for builders far exceeded the capacity of local industry and resulted in inflated construction costs. Outside contractors were finding Orleans Parish a difficult environment in which to work. City officials were hesitant to recognize these nonresident entities as legitimate constructors. Officials knew what to expect from local builders with whom they shared a relationship but were uncomfortable with the fast pace of activity and the lack of qualified inspectors to ensure code compliance. In addition, construction money was slow in coming.

Building codes have change dramatically from when many of these neighborhoods were first built. Some neighborhoods are more than 100 years old and were in desperate need of upgrading. For example, many New Orleans homes had been built with barge board lumber stacked vertically side by side for both exterior and interior walls. Barge boards are oversized, rough-sawn lumber, 3 by 12 inches. Siding had been applied to the outside, and gypsum wallboard or plaster to the inside. Raw materials were shipped from the north down the Mississippi River to New Orleans on barges. Once the raw materials were unloaded, the barges were dismantled and sold as barge boards for construction. Although very effective at the time, this method is now extremely inefficient in terms of materials and subsequent energy conservation when compared with current standards.

Other building code issues that put city officials at odds with neighborhoods included the issues of setback standards and off-street parking. The New Orleans Comprehensive Zoning Ordinance (Matthew Bender and Company, 2007) indicates residential setback standards are 20 feet from the street and 3 feet from the side lot line. Houses that require more than 50 percent of their market value in rehabilitation cost or need to be entirely reconstructed must meet the new building code or acquire a variance. Anyone who has ever visited an older New Orleans neighborhood with houses that have front doors opening onto the sidewalk and, in some cases, have zero clearance between neighboring houses, can understand how meeting the new setback requirements may be difficult.

Even if city officials granted a variance for the setbacks, allowing the new house to match existing houses, a number of other issues needed to be resolved. New building codes require off-street parking. In addition, the new base flood elevation (BFE) would require the new house to be 3 feet above the highest existing adjacent grade (FEMA, 2006). Thus the entry steps and the required landing would extend out onto the sidewalk and possibly the street. It quickly became clear that more problems than solutions existed, resulting in the ensuing gridlock regarding the inner city.

Project Description

The project for the Tremé/Lafitte neighborhoods in Orleans Parish of New Orleans was a partnership between the University of Nebraska–Lincoln (UNL) College of Engineering and Catholic Charities of the Archdiocese of New Orleans (CCANO) to develop protocols for the rehabilitation effort and to test them on 10 units, to create 20 new designs, and to capture the unique designs of 10 existing neighborhood houses before they were demolished. The partnership disseminated the material developed during the course of this project via a website (University of Nebraska, 2007), making it available for others during the reconstruction effort. The posted information included protocols for the rehabilitation portion of the project and an actual rehabilitation manual, reconstruction drawings and details, and new construction design drawings and details.

University-Community Partnership

The author heads the construction engineering and management programs at UNL and is the principal investigator for the project. Several faculty members in the Construction Engineering and Management programs were involved, as were a number of students, some of whom were employed during the project. To involve a larger number of students, the university designed the project to be used in a sophomore-level course as a design project and in junior- and senior-level courses as an analysis project. UNL conducted the research, provided the designs, and distributed the information. The partnership with CCANO was the result of discussions between the author and CCANO for this specific purpose. CCANO acted as the owner's representative organizing design charrettes with local builders, reviewing the designs at various stages, and suggesting modifications. CCANO also worked with the volunteers and managed the operations on location.

CCANO is an umbrella agency of approximately 33 social and health services programs located throughout the Archdiocese of New Orleans. It works with a nonprofit entity called Providence Community Housing (Providence) whose mission is to "foster healthy, diverse and vibrant communities by developing, operating and advocating for affordable, mixed-income housing, supportive services and employment opportunities for individuals, families, seniors and people with special needs" (Providence Community Housing, 2007). Charlotte Burgeous, of CCANO, and Deacon John Ferguson, of Operation Helping Hands, were instrumental in coordinating these efforts.

The Sixth Ward, also known as the Tremé and/or Lafitte neighborhoods, was the focal point of the project, with some activity in the Seventh Ward and Bayou St. Johns. The Tremé/Lafitte neighborhood is north and west of the French Quarter and included some of the most blighted areas in New Orleans. Bayou St. Johns is the adjoining neighborhood to the northwest. St. Raymond's Church is in the Seventh Ward or Gentilly neighborhood just north and east of the Tremé/Lafitte neighborhood and was the headquarters for Operation Helping Hands.

Strategies

The project used three strategies: (1) rehabilitation, which refers to damaged houses that were repairable; (2) reconstruction, which refers to houses damaged beyond repair but that would be rebuilt similar to their original design and layout; and (3) construction, which refers to new house designs. The objective of the rehabilitation strategy was to create and refine a rehabilitation protocol manual by working with CCANO on 10 housing projects, implementing lessons learned. The objective of the reconstruction strategy was to capture the designs of 10 houses beyond repair and incorporate the affordable, environmentally resistant features into a set of construction documents. As part of this strategy, the team disseminated information in the form of construction drawings for actual reconstruction. The objective of the construction strategy was to develop 10 sets of new drawings and 10 variations for CCANO to help its constituencies build new homes that would incorporate the affordable, environmentally resistant features. The team also disseminated information for this strategy in the form of construction drawings for use by owners and home builders. The policy and procedures manuals, the construction drawings, and the reconstruction drawings were made openly available on the Internet. The drawings are available for download in .dwg format for AutoCAD and .pdf format for Adobe Acrobat.

Rehabilitation Strategy

Rehabilitation often included the complete removal of all but the basic structure. Wall cavities were especially prone to mold if exposed to moisture for any length of time. Plaster and gypsum wallboard were often damaged beyond repair if exposed to flooding for even a short time. Interior damage also resulted from broken windows and damage to roofs. The result was, in many cases, that the cost to rehabilitate a house was more than the cost of reconstruction. For some residents, the decision to rehabilitate in spite of the economic disadvantage was more about the psychological effect of returning to normalcy. It meant getting their life back. Other more pragmatic reasons to rehabilitate included unacceptable building code restrictions associated with new construction such as off-street parking and setbacks. Subsequent sections of this article address this issue in more detail.

Deacon John Ferguson from CCANO, a seasoned builder, craftsman, and organizer, directed Operation Helping Hands' efforts. Through this organization's efforts, volunteers and staff completed the interior demolition and cleanup of more than 2,000 houses in 2 years. The schedule for federal government-funded waste pickup created urgency in completing the demolition within the prescribed time period. About 20 percent of these houses are now rebuilt with numerous others partially completed.

Deacon Ferguson developed the protocol manual that was later revised by Paul Cook, his successor, to help with the efforts at Operation Helping Hands. Protocols were necessary to minimize the risk to volunteers who sometimes worked in harsh, if not toxic, environments. Contractors were needed to do much of the repairs, unless the organizations were fortunate enough to find skilled volunteers. Many homeowners, however, lacked the financial means to complete the rehabilitation. Receipt of insurance, state, and federal money, including funds from the Road Home program, was delayed and the amounts were often inadequate in light of inflated labor and materials prices.

CCANO and Providence had access to titles on 9 duplexes, or 18 units, on one block located between St. Peter Street and Orleans Avenue in the 2800 block, as shown in exhibit 1. The project team selected these duplexes as the test case because, first, the impact on the neighborhood of rehabilitating an entire block was more substantial when compared with 10 scattered site units and, second, the units were in different, yet similar, stages of disrepair and made an excellent sample for comparison. The project team developed a rehabilitation strategy and program for the 18 units using information from Operation Helping Hands and independent research.

Exhibit 1

Duplexes on St. Peter Street: A Test Case in Orleans Parish, Louisiana

A northwest view on the 2800 block of St. Peter Street, in the Tremé/Lafitte neighborhoods of Orleans Parish. Photo credit: James Goedert.

A project management plan for each duplex, including a repair list, schedule, estimate, and protocols for incorporating hurricane-resistant features, was delivered to Providence to rehabilitate the units. The photo in exhibit 2 portrays a typical duplex unit; note the water line that is visible on the fourth row of siding. The project team posted one of the nine manuals that Deacon Ferguson developed for the individual properties on the web. The information this manual is useful for others attempting similar efforts. For example, a big concern associated with cleanup includes exposure to mold and other toxins during the demolition process. The manual describes the necessary precautions and recommends mold remediation products and sealants to prevent mold from returning.

Another concern in rehabilitating houses was how to develop a load path through the structure. Exhibit 3 shows the load path through the structure of a typical house from the *Coastal Construction Manual* (FEMA, 2005). The load path indicates eight links that tie the structure together from the roof to the foundation. Link one is the roof sheathing to the rafters. The original wood shingles were covered by asphalt shingles, which is typical of many of the older homes. The sheathing beneath the wood shingles is 1- by 6-inch boards with 1-inch spacing between boards to allow

Exhibit 2

Hurricane-Damaged Duplex Home in Orleans Parish, Louisiana

A typical duplex unit in the Tremé/Lafitte neighborhoods in Orleans Parish, with the water line from Hurricane Katrina flooding visible on the fourth row of siding. Photo credit: James Goedert.

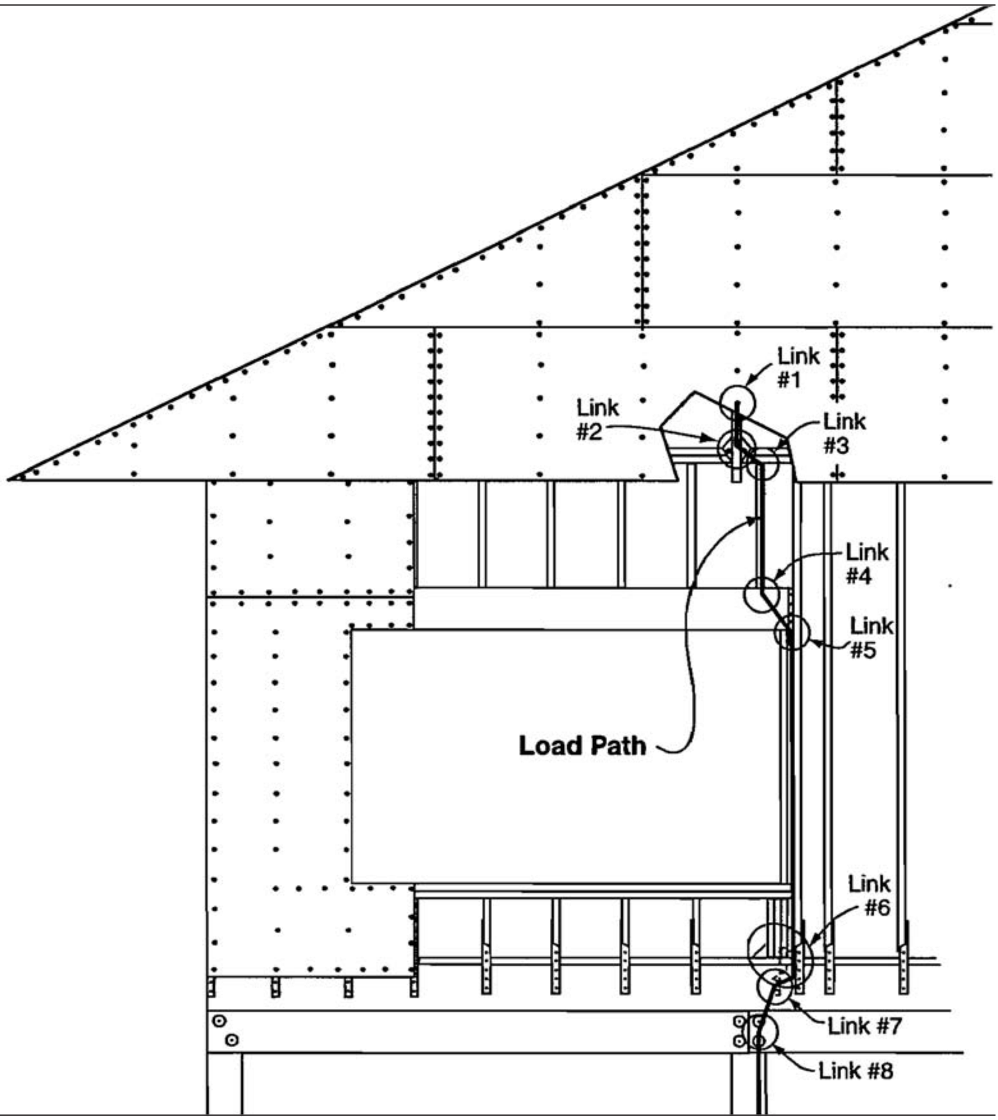
airflow through the wood shingles. During rehabilitation, the builders removed the shingles and installed 7/16-inch sheathing with 8d nails every 12 inches in the field and 6 inches along the edges.

Links two through seven were more problematic because the wall siding and roof sheathing on the outside and the plaster walls on the inside concealed them. The water damage from flooding was to the bottom 12 inches or slightly more on the interior walls. Other water damage caused by the winds varied depending on the extent of the roof damage. Although access to the structure at the rafter-to-plate-to-stud connection was necessary to install the proper brackets to maintain the load path, the installation could be accomplished from the interior or the exterior. The project team decided it would be easier for the builder to access the structure from the interior because (1) the siding and exterior sheathing were intact and could be repaired and repainted, (2) the roof sheathing would also need to be removed for a few feet up along the eve and then replaced if the links were accessed from the exterior, and (3), given the extent of the interior water damage, the bottom 4 feet of the drywall was already being removed and replaced as was the ceiling damage. It was more practical to gut the interior and mount the appropriate brackets to the exposed structural elements from the inside and replace all the drywall.

The city declared the damage to the properties in excess of 50 percent. This is the threshold for structures that must meet the new BFE. According to the Federal Emergency Management Agency (FEMA), "The BFE refers to the elevation associated with the "100-year flood, or it is a flood with a 1-percent chance of occurrence in any given year" (FEMA, 2007: 1). Flood insurance rate maps

Exhibit 3

Load Path Diagram From the *Coastal Construction Manual* (Figures 12–15)



show the BFE for a given location. It is necessary to build above the BFEs to be eligible for the National Flood Insurance Program and FEMA funding for some recovery projects. These units had to be raised to install new foundations that meet the new standards. Some homeowners could apply for up to $30,000 to elevate their homes through their flood insurance programs. The eighth and final link occurred by attaching the new foundation to the structural beam. All remaining repairs were standard practice and required no special accommodations. Exhibit 4 shows one of the duplexes on this block nearly rehabilitated.

Exhibit 4

Rehab in Progress

A nearly rehabilitated duplex in the Tremé/Lafitte neighborhoods in Orleans Parish. Photo credit: James Goedert.

Reconstruction Strategy

New code requirements such as setbacks and off-street parking, previously discussed in the rehabilitation section, prevented a number of houses from being reconstructed. Other houses met the requirements. For example, the duplex photographed in exhibit 5 was designed for reconstruction. The project team captured the original floor plans of each house before the city demolished the duplex. A number of modifications were suggested to make the living space more comfortable and a little more modern.

Most of the houses selected for reconstruction were designed as a "shotgun" floor plan due to the limited and narrow lot sizes. The shotgun has each room lined up behind the next with no hallway, thus maximizing the space. This style is well known in New Orleans, and the name originated from the notion that one could shoot a shotgun through the front door out the back door. Homeowners were soon discouraged with reconstruction when faced with an opportunity to work from a blank slate. The team selected nine houses as candidates for reconstruction. The floor plan shown in exhibit 6 is based on the floor plan illustrated in exhibit 8. These designs are accessible to the public for replication at other locations through the website. The team modified the designs to incorporate new code requirements and other affordable and technically relevant features.

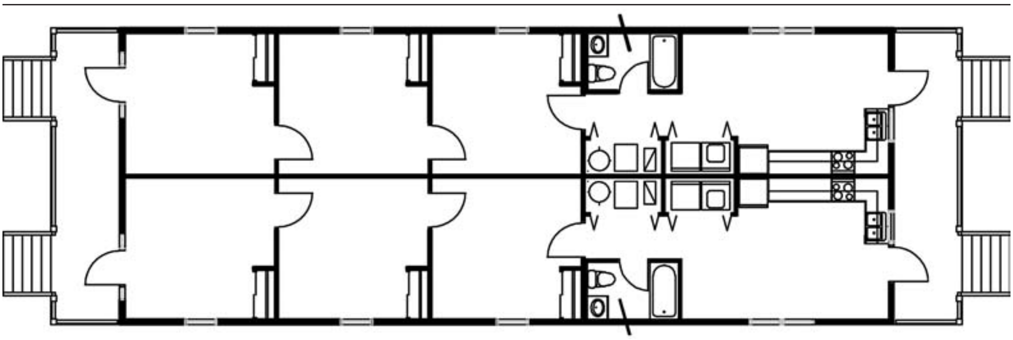
Exhibit 5

Hurricane-Damaged Duplex in Orleans Parish, Louisiana

A duplex unit in the Tremé/Lafitte neighborhoods in Orleans Parish selected for reconstruction. Photo credit: James Goedert.

Exhibit 6

Modified Floor Plan of Duplex Unit



Construction Strategy

A pre-Hurricane Katrina analysis of the housing market in Orleans Parish indicated that nearly 70 percent of occupied housing units were one- and two-person households (U.S. Census Bureau, 2006). The remaining 30 percent of housing units comprised three- and four-person households (about 15 percent each). These ratios were similar after Hurricane Katrina, but the number of occupied housing units decreased from approximately 180,000 to 74,000. Approximately 47 percent of the pre-Hurricane Katrina housing units were owner occupied; the remaining units were renter occupied. The cost range for the new houses was from just under $100,000 to $170,000. About 43 percent of the households earned less than $50,000 a year and almost one-half of those earned less than $25,000 per year. Even at a three-times multiplier, affordable housing was going to be difficult to accomplish.

The team needed to research affordable designs that resist the harsh environmental conditions in New Orleans and that consider life-cycle energy costs, structural durability, and cultural factors. Research of designs that blend in with the neighborhood started with *A Pattern Book for Gulf Coast Neighborhoods* by Urban Design Associates (2005). More valuable information was retrieved during numerous visits to see the neighborhoods. Even more important were the discussions with people living in the neighborhoods and the feedback received during the design charrettes.

CCANO started with a list of nearly 200 adjudicated properties scattered throughout the Tremé/Lafitte neighborhoods. The project team evaluated the properties to determine whether rehabilitation, reconstruction, or new construction would be most appropriate. For the properties determined appropriate for new construction, the project team surveyed them for size and layout and then categorized them to determine house sizes that would best match the available properties. The project team then developed 13 designs and named them after trees indigenous to the area, including the 448-square-footr Yaupon that is 16 feet wide and 28 feet long and the 1,364-square-foot Willow Oak that is 22 feet wide and 62 feet long. It modified 11 of these designs, resulting in 24 single-family residents. It also designed 4 using 4 of the original 13 designs. Exhibit 7 is a rendering of the Drummond, and exhibit 8 is the floor plan. The project team made plans available through the website and through hardcopy distribution at design charrettes, neighborhood meetings, and offices at CCANO, Providence, and HUD.

Exhibit 7

Rendering of the 900-Square-Foot Drummond Model

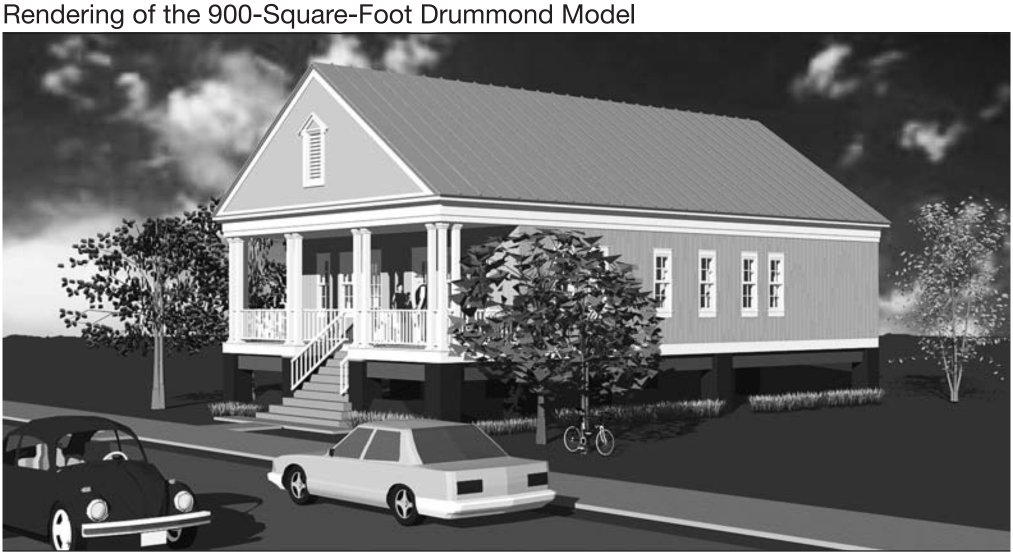
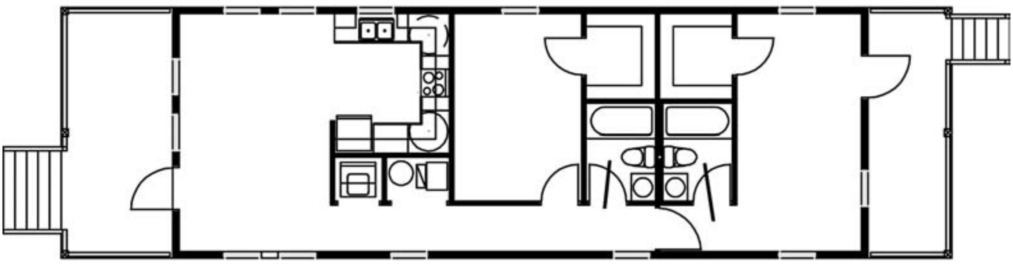


Exhibit 8

Floor Plan of the 900-Square-Foot Drummond Model



Technical knowledge is available to help builders construct affordable housing that will resist damage due to hurricane force winds. In fact, a number of solutions are prescribed by the International Residential Code for One- and Two-Family Dwellings (International Code Council, 2006), which is the current code for the City of New Orleans. Code restrictions are minimum requirements and often do not include current or best available practices. Most houses damaged by the hurricane in the inner city were built long before these building codes existed. Many houses damaged by the rising flood waters were not built to the BFE. Some houses were designed to accommodate garages beneath them, but these garages were often converted into living spaces. These BFEs have recently been adjusted for all of New Orleans to form the basis for insurance rates.

Other techniques for resisting the harsh environmental conditions were found in publications such as the previously mentioned *Coastal Construction Manual* (FEMA, 2005). The Partnership for Advancing Technology in Housing (PATH), a program within the HUD Office of Policy Development and Research (PD&R), published *Durability by Design* (HUD PD&R PATH, 2002), which addresses a number of issues not specific to New Orleans but nonetheless relevant. This manual includes proper flashing techniques and decay and corrosion protection techniques among other topics. *Moisture-Resistant Homes* (HUD PD&R PATH, 2006), another PATH publication, includes a number of recommendations organized by systems.

Fernando Pages Ruiz is the owner of Brighton Homes and author of *Building an Affordable House: Trade Secrets to High-Value Low-Cost Construction* (Pages Ruiz, 2005). PATH sponsored the first concept house in Omaha, Nebraska, to disseminate information about the "efficient, sustainable, and flexible elements that make it the home of the future" (PATH, 2007). Brighton Homes constructed this home and Pages Ruiz worked as a consultant on the project, offering suggestions on a number of designs. The project team used his book and the HUD publications, as well as other valuable resources, in designing the affordable homes with the most currently available techniques while remaining sensitive to the needs of the neighborhood residents.

The project team reviewed a number of alternative house-building methods for the purposes of this project, including 2- by 4-inch wood framing, 2- by 6-inch wood framing, panelized wood framing, three concrete building methods, and structural insulated panels. The team learned quickly that the citizens of New Orleans like tradition, and that they needed to develop house designs that have the look and feel of New Orleans, with the affordable and advanced technical features being less apparent. The first design charrette with homebuilders included discussions about modular, structural insulated panels (SIPs) and 2- by 6-inch framing. At this charrette, the project team focused on the exterior façade and floor plan and not on the method of construction because it could easily adapt the schematic designs to alternative methods. It developed the drawings using 2- by 6-inch construction at 24 inches on center instead of the more traditional framing, as explained in more detail in the next section.

Wood Frame Construction

Most wood-framed housing construction is 2- by 4-inch framing at 16 inches on center with two top plates and one bottom plate for exterior walls. In some cases, it is possible to use 24 inches on center with one top plate if the rafters, studs, and joist line up, maintaining the load path. This method eliminates one stud every 4 feet and one plate all around the perimeter, thus reducing the cost of the building. In addition, because wood is not as good of an insulator as fiberglass, and because the construction method uses less wood and more insulation, the energy efficiency of the house is improved for the life of the house. The design wind load in New Orleans, which is 130 miles per hour, requires that 2- by 4-inch construction be 16 inches on center, which is typical wood frame construction. An alternative is 2- by 6-inch wood frame construction at 24 inches on center, which is not only stronger but increases the depth of the insulation by 50 percent. The labor cost of framing and installing insulation is the same for both methods while the material cost is greater for 2- by 6-inch wood frame construction. The 2- by 4-inch method uses three studs for every 4 feet of exterior wall, but the 2- by 6-inch method uses only two. The cost of a 2- by 6-inch method, however, can be nearly twice that of a 2- by 4-inch method, causing a 30-percent increase in cost of this single lumber component. Doebber and Ellis (2005) showed that 2- by 6-inch framing resulted in 33.3 percent annual furnace energy savings over conventional framing when analyzed for homes built in Miami and 24.3 percent for homes in Phoenix. The central air conditioning cost savings were more modest at 0.7 percent for Miami and 1.0 percent for Phoenix. The initial cost of the additional insulation is slightly higher but could result in a smaller, less expensive furnace and air conditioning unit. The 2- by 6-inch wood frame construction results in a reduced total life-cycle cost because of the reduced energy cost.

The concept house that the Operation Helping Hands built in New Orleans used panelized construction, a wood-framing method in which panels are created in a factory, shipped to the job site, and erected using a small crane and crew. This method is extremely fast on the job site, requiring fewer skilled crafts than traditional framing. By using this method of framing, the team framed the concept house in a few days rather than a few weeks. This approach is particularly important for New Orleans with its limited skilled labor pool. In addition, the quality of construction should be improved because of the factory environment in which the panels are produced.

Concrete Homes

Residential concrete homes are gaining in popularity and market share. Several types of concrete homes and several manufacturers of each type are available. Concrete homes are durable and resist fire, wind, mold, and insects. In addition, the energy savings, as well as the cost savings, are significant when compared to wood-framing methods. Additional energy-related benefits include increased thermal capacitance and reduced air infiltration. The reduced air infiltration can become a problem, and mechanical ventilation may be necessary to ensure a healthy living environment. Residential concrete construction includes insulated concrete forms, sandwich panels, and precast panels.

Insulated concrete forms are permanent, double-wythe forms made from lightweight expanded polystyrene that are filled with reinforced steel and concrete. This technology was used on 3 percent of homes in 2005 according to the National Association of Home Builders (Doebber and Ellis, 2005). The panels are lightweight and easy to install and are left in place. They can be used for the basement, as in the PATH concept house, or they can be used for both the basement and above-ground walls. The basement of the PATH house took approximately 6 hours to complete, and this includes setting the forms and placing the concrete. No form removal is needed, and the waterproofing and interior framing are included. Doebber and Ellis (2005) found that insulated concrete forms saved 77.7 percent in furnace energy and 2.4 percent in central air conditioning in Miami and 44.8 and 7.4 percent, respectively, in Phoenix, when compared to conventional framing. The Canadian National Building Code recently adapted its code to include insulated concrete forms for basement and above-ground installation by providing prescriptive engineering requirements (Storer, 2007).

Several variations of concrete sandwich panels include polystyrene insulation. Holmes, Kusolthamarat, and Tadros (2005) describe a precast sandwich panel duplex with 2.5 inches of concrete on both sides of a 5-inch expanded polystyrene panel. Fiberglass connectors connect the concrete wythes together to maintain the thermal integrity of the assembly. The exterior concrete finish includes some architectural finishes and some 0.5-inch brick facing requiring little or no maintenance. Doebber and Ellis (2005) analyzed a panel with 2 inches of concrete on the outside and 4 inches on the inside of 3 inches of polystyrene insulation. They found that this configuration produced furnace energy savings of 84.5 percent and 32.5 percent for Miami and Phoenix, respectively, and central air conditioning savings of 2.4 percent and 5.7 percent, respectively.

Residential precast concrete panel construction is much more prevalent overseas than in the United States and dates back a number of years. Widespread usage occurred in the Soviet Union, Western Europe, and the United Kingdom 35 years ago (Selbe, 1973). The advantage overseas was mostly related to the availability of raw materials. Energy savings are much more important now, and the insulated concrete forms and sandwich panels are better concrete alternatives when compared to precast panels. Thin-wall precast systems from 1.5 to 3.0 inches thick are also available and can include an architectural finish. These panels are usually reinforced with a stud system. The stud system also “resists lateral loads, carries vertical loads, and can serve as a frame for the attachment of interior finishing materials” (Miller, 2006: 56).

Structural Insulated Panels

Structural insulated panels are sandwiched panels with foam insulation inside two layers of oriented strand board, plywood, or fiber cement. These panels are laminated together into a panel that is easily assembled at the site with little training. The advantages of structural insulated panels over conventional construction are strength and energy efficiency. The International Code Council adopted the panels into the International Residential Code in May 2007. A 4-inch thick SIP wall would have an *R* value of 15 as compared with 11 for a 4-inch wood frame wall. The continuous insulation reduces thermal bridging and air infiltration. As with the concrete and alternative framing method, the initial cost of this method is higher, and cost savings must be realized through future energy savings.

The new house designs this project provided are easily adaptable to any of the shells previously mentioned. The *Engineering News-Record* featured three concrete home companies with different products saying, "their products can be custom-made to fit any architectural style, which is important in New Orleans' and Mississippi's historic neighborhoods" (Bergeron, 2006: 16). PAR Contractors, Inc., of New Orleans, indicated at the first design charrette that the company could use the schematic drawings to create the SIP to build their houses. Millard Lumber, Inc., from Omaha, Nebraska, creates its own drawings from those provided by an owner or builder to send to the automated shop for panelization. The 24 house designs and 4 duplex designs this project provided can be built with any of the previously mentioned methods. The same is true of the designs described in the previous discussion regarding reconstruction.

Conclusion

New Orleans is slowly rebuilding but may never fully recover from the social and economic impacts of Hurricane Katrina. Finger pointing is moot in a major catastrophe. The fact is that many poor people lived in the low-lying areas of the city and were hurt the most. Rebuilding the same house in the same location and with the potential for future flooding was not practical. In a number of areas, building to meet current codes made little sense without a new urban plan because of the small lot sizes and numerous other social and engineering problems. Most solutions, while sensitive to the plight of the poor, were inadequate to respond to their needs on the scale necessary to reestablish the pre-Hurricane Katrina livelihood.

A number of expensive features can be included in a design to mitigate or eliminate damage caused by wind, rain, and flooding. It became quickly apparent that revolutionary construction models were not going to get the people of New Orleans what they needed most, which was to get back into their homes. This research was focused on affordable solutions that could be easily incorporated into the new and existing construction.

Of the project's three strategies—rehabilitation, reconstruction, and construction—the rehabilitation strategy was achieved. This project affected an entire neighborhood by rehabilitating 9 duplexes, for a total of 18 units, all in a one-block area. Also, during the demolition and cleanup of more than 2,000 units, the project team used the protocol manual that Catholic Charities of the Archdiocese of New Orleans, through Operation Helping Hands, developed. The team also made the manual available via a website to builders, officials, and homeowners.

The reconstruction strategy seemed to have the greatest potential to help 10 homeowners replicate their house design, but it did not meet this objective. It quickly became apparent that if rehabilitation was not an option, then it would be extremely difficult to get the code variances necessary to reconstruct using the same footprint. Nine design plans for houses damaged beyond repair were created and made available to the public. One single-family unit and one duplex were actually rebuilt as a result of this effort.

The construction strategy objective was exceeded in terms of the available design, but actual construction is lagging. The goal was to design 10 sets of new house designs and 10 variations of those designs that blend with the neighborhood. The project created a house design manual that displays 13 new house designs, 15 variations, and four duplexes. The manual can be distributed to residents. The designs match the neighborhoods, are affordable, and are able to resist the harsh environmental conditions. The complete construction drawings are available for downloading in .dwg or .pdf format at http://www.const.unomaha.edu/neworleans/index.php. CCANO encountered a number of complications with the adjudicated properties and the organization is nearly 18 months behind the original goal to begin construction. No one is more frustrated than CCANO at the inability to clear title on more than 200 lots to begin the process of new construction in the Tremé/Lafitte neighborhoods. It took almost 3 years after Hurricane Katrina occurred for any new house construction to begin. Operation Helping Hands is shifting the focus from demolition and rehabilitation to new construction and is using the drawings from this project to distribute to the community.

The rebuilding effort has been discouragingly slow. The rehabilitation effort is well under way, but few new homes have been constructed in the inner city. A number of unresolved issues, as well as the introduction of new codes and standards, have made it extremely difficult to make the progress needed for the residents to return to the life they once knew. The project was an extraordinary opportunity for student involvement with a social issue that included construction engineering and management problems. The challenge was to match student skills in a manner that provided good-quality documents for the user. These documents can be extended to other coastal areas in need of affordable designs and are available to the public. The Construction Engineering and Management programs at the University of Nebraska–Lincoln currently use community service projects as a service-learning component in the curriculum. Senior construction students supervise the renovation of houses in partnership with local nonprofit organizations. A reasonable extension of this project and the service-learning component could include a national effort to mobilize the tens of thousands of construction students in the United States to provide supervision for national disaster reconstruction.

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Author

James Goedert is an associate professor at the University of Nebraska–Lincoln, College of Engineering, and is the chairman of the Construction Engineering and Management programs in the Charles W. Durham School of Architectural Engineering and Construction.

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