New Technology Used	Retail Cost Increase
Structural Protection	
Cast-in-place concrete walls	none
Wind-driven Rain Protection	
Recessed seats in foundation slab	none
Out-swing exterior door	none
Hurricane shutters	$1,388
Redesigned soffit & fascia	$107
Acrylic exterior coating	none
Peel-and-stick roof underlayment	$979
Post Storm Recovery Protection	
Paperless drywall	$760
Generator-ready electrical panel only	$390
Natural gas-powered generator & panel	$6,883
ENERGY STAR® Home:	
Foam board insulation	none
HVAC located in conditioned space	$75
R-30 ceiling insulation	$150
Low-e windows	$1,200
Total	**$11,932**

Builder's Goal:

"To build homes that families can stay in safely during low-grade tropical storms."

Builder's Experience

Scott Buesher, President of Operations at Mercedes Homes, describes the project goals and Mercedes' experiences with cast-in-place concrete, hurricane-resistant housing:

Regarding client satisfaction, clients have been very enthusiastic about the cast-in-place concrete wall system. The homes are solid, giving homeowners a sense of comfort and added security. Mercedes also works with FEMA, the University of Florida Program for Resource Efficient Communities, and insurance underwriters on developing projects that will pre-qualify buyers of concrete homes for discounted homeowners' insurance.

Regarding Mercedes' goal of continuous product improvement, while the new cast-in-place homes performed exceptionally well in the 2004 tropical storm season, Mercedes wanted to address the tougher issue of minimizing water damage and intrusion. The hurricane-resistant prototype represents the next step in our ongoing efforts for quality improvement in every aspect of the house's construction – energy efficiency, hurricane resistance, improved construction quality, and increased comfort.

Regarding the sense of security, the trauma of leaving your home and your neighborhood to seek shelter in an outside city during tropical storms creates a great deal of emotional and financial stress for Floridians. Ultimately Mercedes Homes hopes to build houses that will allow families to remain safely at home during low-grade tropical storms rather than evacuating.

PATH
PARTNERSHIP FOR ADVANCING TECHNOLOGY IN HOUSING
U.S. DEPARTMENT OF HOUSING AND URBAN DEVELOPMENT

Hurricane-Resistant Homes by Mercedes

TECHNOLOGY HIGHLIGHTS

Structural Protection
- ***Cast-in-Place Concrete Walls***
- ***Direct Load Path***

Wind-Driven Rain Protection
- ***Recessed Seats in Foundation Slab***
- ***Out-Swing Entry Doors***
- ***Removable Storm Shutters***
- ***Reconfigured Soffit & Fascia***
- ***Baffled Roof Vents***
- ***Secondary Roof Drainage Plane***
- ***Sealant at Form Joints***
- ***High Performance Acrylic Finish Coating***

Post Storm Recovery Protection
- ***Natural Gas Powered Generator***
- ***Paperless Drywall***

ENERGY STAR® Homes

What began as an initiative for better wall systems evolved into the development of disaster-resistant housing for the southeastern United States. In Florida, Mercedes Homes began working with Building America research teams in 2000 to develop an advanced wall system replacing residential CMU block construction commonplace throughout Florida. After experiments with a variety of systems including pre-cast concrete, Mercedes Homes focused on construction of cast-in-place concrete wall systems. By June 2005, Mercedes Homes had used cast-in-place concrete walls on nearly 3,000 Florida homes.

The concrete walls system is designed with steel reinforcing and was extensively tested in the 2004 hurricane season when a record number of tropical storms pounded the Florida coast. In evaluating the aftermath, researchers from University of Florida's Energy Extension Service (FEES) and Steven Winter Associates, Inc. found that the concrete homes performed exceptionally well in resisting wind-blown debris and hurricane-induced lateral loads. However, the majority of damage suffered by intense 2004 hurricanes season is a result of wind-driven rain not excessive wind loads.

With funding from the Federal Emergency Management Agency (FEMA) a department of Homeland Security, Mercedes Homes and its partners set out to improve the quality of housing to build more hurricane-resistant homes. Lessons learned from 2004 were combined with innovative new concepts to design and build a hurricane-resistant prototype at Huntington Lakes, a Mercedes Homes Community in Rockledge, Florida. The prototype incorporates a number of PATH technologies to offer homeowners three levels of hurricane protection: superior structural strength, greater resistance to wind-driven rain, and improved post-storm recovery.

ADVANCED TECHNOLOGIES

It is the goal of the U.S. Department of Housing and Urban Development's Partnership for Advanced Technology in Housing (PATH) program to accelerate the development and use of new technologies that will substantially improve the quality, durability, energy efficiency, environmental performance, and affordability of America's housing stock. These new disaster-resistant Mercedes homes feature several of PATH's proven technologies combined and affordably implemented for the developer and beneficial to the homeowner. There is a three-tiered system for hurricane resistance: Structural Protection, Wind-Driven Rain Protection, and Post Storm Recovery Protection. Highlighted below are the PATH technologies utilized in this project:

STRUCTURAL PROTECTION

Cast-in-Place Concrete Walls— (1) The prototype home offer superior structural resistance to hurricanes largely due to the cast-in-place concrete wall system. Typical residential construction in Florida and much of the southeastern United States consists of concrete masonry unit (CMU) construction for single-story homes. Two-story homes typically use CMU on the first floor and wood framing on the upper story. In both instances, homes subjected to a tropical storm may suffer from water intrusion, lateral and uplift wind loads, and structural failure caused by wind-driven debris ("missiles").

The concrete wall system used at Mercedes Homes can withstand wind-borne debris at 200 miles per hour.

The cast-in-place system used in the prototype employs 3,500 psi concrete. The concrete encloses a steel reinforcing impact cage, 6x6 road mesh combined with vertical reinforcing bars at 4-foot intervals. The cage is specifically designed to evenly distribute point loads from wind-driven debris ("missiles") across the structure. The 6-inch-thick concrete walls are placed using removable, modular aluminum forms. The forms represented a significant up-front cost for the builder, but they ensure fast and accurate construction while minimizing waste. Window and door openings are created with reusable inserts within the modular formwork that also form the head, jamb, and sill profiles for the openings. Tie-down fasteners (called "hurricane straps") connecting the wooden roof trusses to the exterior concrete walls resist uplift. The hurricane straps are wet-set into the concrete at regular intervals to align with the trusses (typically 2-feet O.C.).

1

The concrete and steel reinforcing wall system acts as a monolithic composite assembly that can evenly distribute impact stresses and point loads decreasing structural damage for superior performance during hurricane events. For example, during extensive testing conducted at the Wind Science and Engineering Research Center at Texas Tech University, a wall system similar to that developed for the prototype Mercedes Homes was shown to successfully withstand wood stud "missiles" projected at 200 mph. Typical wind speeds for a Category 5 tropical storms range to 155 mph with wind-borne debris traveling well upwards of 100 mph – sufficiently below the limits of a 3,500 psi concrete, steel-reinforced wall system.

Other benefits of the cast-in-place concrete wall system include energy efficiency, comfort, and durability. Concrete walls have high thermal mass, reducing energy transfer between interior and exterior surfaces. This property of concrete lowers the overall energy cost of the home. The system offers superior comfort by minimizing interior temperature fluctuations, drafts, and reducing noise transmission. Concrete inherently resists mold, termites, and rot because it contains no organic mater. The moisture that typically enters CMU walls at joints is eliminated by the monolithic system. Additionally, the houses are safe from more than just hurricane disasters— the structure with its 6-inch solid concrete walls offers up to 3-hr Class A fire rating, making them safer from water and fire.

Money Isn't All You're Saving

7

paperless drywall. Mold grows particularly quickly on paper, adhesives, and other organic matter. A new residential product offered by Georgia Pacific uses glass reinforcing mat facing over gypsum to resist mold growth better than traditional paper-faced products.

ENERGY EFFICIENCY

ENERGY STAR® Homes—In addition to their hurricane resistant features, the prototype Mercedes Homes at Huntington Lakes is an ENERGY STAR® certified home. Steven Winter Associates performed energy modeling and analysis to identify areas for potential efficiency gains. Home performance testing verified that the prototype achieved the design goals for tightness. The houses achieved a Home Energy Rating Service score of 89, which represents energy performance 45% better than the Model Energy Code (MEC). The following elements were used to increase the overall energy efficiency of the house:

Insulation— (7) The building envelope was improved through tight concrete construction, continuous foam insulation board adhered directly to the interior surfaces, and R-30 ceiling insulation.

Low-E Insulated Windows—High-performance glazing provides daylight without sacrificing energy efficiency. Thermal modeling showed that the use of low-e windows will allow the builder to downsize cooling equipment for the homes offsetting the total cost of the low-e coating.

Efficient Mechanical Equipment—Heating and cooling equipment was carefully sized to maximize efficiency. A high-efficiency heat pump heats and cools the house. A programmable thermostat saves heating or cooling costs when the house is unoccupied.

Mechanicals in Conditioned Space—Mercedes Homes designed special utility closets in the vestibule between the garage and the house for the air handler. Locating the heat pump within this conditioned space improves operating efficiency.

Compact Duct Design—Eliminating long runs of ductwork has two benefits: energy efficiency increases while initial construction costs decrease. Registers are located on interior corners of rooms closer to the air handler. A centralized return directly below the unit saves material cost and energy without compromising performance.

Mastic-Sealed Ducts—Applying mastic compound to the joints of the ductwork and connections reduces air leakage.

COST ANALYSIS

The table on the following page shows the approximate cost increase of implementation of the prototype energy-efficient hurricane resistant homes. Prices listed below are in comparison to standard practices for a single-story 2,000-square-foot home.

Direct Load Path— Incorporating a direct load path from the roof trusses to the foundation greatly improves structural resistance of the whole house to typical hurricane damage. Traditionally, exterior walls may remain intact after a storm event but often the strong winds lift off the roof, partially or in whole, allowing water and debris to rain in and damage the home's interior. To protect from this problem, consultants at Steven Winter Associates aligned the roof trusses directly over the interior stud walls. The stud is securely anchored to the concrete slab beneath and tied to the roof truss above with hurricane straps providing a direct, uninterrupted tie between the roof, wall, and foundation systems.

Wind-Driven Rain Protection

Recessed Seats in Foundation Slab— Water intrusion at ground level is mitigated by creating recessed seats in the foundation slab (2) under openings and exterior walls to prevent wind-driven rain from entering the home. During tropical storms rainwater sheets down the outside of the house and is often sucked into or driven under doors and walls by wind pressure or pressure differentials. Creating shallow indentations in the foundation slab, or recessed seats, eliminates the direct route for water penetration at these vulnerable areas.

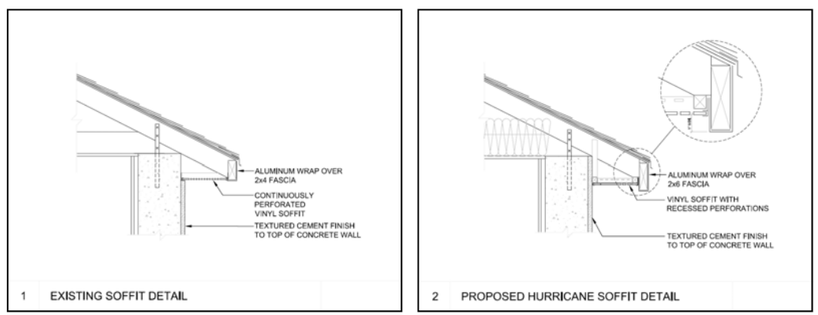
2

Out-Swing Entry Doors— Although somewhat unconventional, out-swing entry doors (3) offer common sense performance during hurricanes. In the aftermath of the 2004 storm season, researchers found that in-swing entry doors blow in during hurricane force winds. At a minimum, in-swing doors result in water and debris damage. In more severe instances a change in pressures following a door blowing inwards contributes to roof uplift and subsequent significant structural damage. Installing doors that swing outward rather than inward greatly reduces these risks.

3

Removable Hurricane Shutters— In all new houses, Mercedes Homes offers removable hurricane shutters as an option to all homebuyers. Corrugated metal or clear polycarbonate shutters protect glass and prevent rain and debris from entering the home through vulnerable window openings.

Reconfigured Soffit and Fascia— Another common point of entry for wind-driven rain is the soffit and fascia covering roof eaves (4). Water sheeting off the roof spills down the fascia board and is often blown into the soffit vent opening. Sheeting water can be driven by surface tension across the bottom edge of the fascia board into the soffit vent opening.



4

A redesigned fascia extends approximately 1inch below the soffit to form a drip edge allowing water to drain down away from the roof eaves. Mercedes Homes recently developed a bent sheet metal edge that adds no appreciable cost. Steven Winter Associates, however, recommended changing the soffit board design and installation. The new product uses recessed openings to limit water intrusion while encouraging greater air circulation within the assembly. The additional air circulation allows any water that does enter through the eaves to quickly dry out.

5

Baffled Roof Vents—Wind-driven rain penetration can be minimized through use of baffled roof vents. The vents, which are available from several different manufacturers, use a series of chambers to reduce the amount of water entering through roof vents the roof.

Secondary Roof Drainage Plane—"Peel-and-stick" underlayment was applied continuously beneath shingles creating a secondary roof drainage plane. Losing shingles during a strong tropical storm is a common occurrence. If shingles are lost or damaged on the prototype Mercedes Home, the self-adhesive, "peel-and-stick" underlayment serves as a backup drainage plane preventing water intrusion.

Sealant at Form Joints— The prototype Mercedes Homes use elastomeric sealant applied at concrete form joints (5), caused by the modular formwork, on the exterior walls. Although concrete is poured continuously across multiple forms, the change in texture at vertical form joints and tie connections creates a vulnerability to water infiltration. Applying sealant to these form joints is a simple and effective way to prevent damage.

High-Performance Acrylic Finish Coating—The prototypes capitalize on recent advances in acrylic finish coatings. The cast-in-place concrete walls receive stucco topped with a finish of high-performance acrylic coating to prevent the exterior walls from absorbing water during heavy rain storms.

Post-Storm Recovery Protection

Most of the losses from the 2004 hurricane season resulted from water intrusion. Water damage and mold growth becomes more severe when power outages prevent homeowners from being able to dry out their homes quickly following a storm. Mold can grow undetected within the home for long periods of time, compromising indoor air quality and causing significant long-term damage to the home.

Water damage and mold growth become more severe when power outages prevent homes from drying out.

Natural Gas-Powered Generator— A generator was installed in the prototype home, and Mercedes Homes plans to include this feature as an optional add-on in its Florida market. Powered by natural gas, the unit (6) is sized to meet most homeowner's power needs. This option is important as it allows homeowners to use fans and dryers during post-storm recovery when power outages are common, thereby greatly reducing the risk of mold growth and long-term damage.

6

As a separate option, Mercedes Homes is planning to offer an exterior electrical service panel that can be readily connected to a portable generator. Even if a homeowner is initially unable to afford the upfront cost of a larger natural gas generator, each home will be pre-wired and equipped for a generator to be installed at a later date.

Paperless Drywall—Recent concern over mold growth has led to the development of