HURRICANE / TORNADO PROOF HOUSING SYSTEM
ABSTRACT

ROIGSTRONGBOX – HURRICANE TORNADO PROOF HOUSING SYSTEM

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INTRODUCTION

One death from a cataclysmic wind, water or seismic event is one too many. It is also completely unnecessary. Rethinking the way houses are built can change this.

Living quarters have been built in relatively the same fashion for thousands of years. The belief has always been that builders should try to accommodate the average climatic and environmental conditions and leave the extreme events to probability. The chance of getting a direct hit from an EF5 tornado is remote. If it does happen, the inhabitants are just out of luck. The cost to build a home that could withstand the highest level of incident is too unaffordable. This logic is unacceptable.

All it takes is someone to sit and think in terms of addressing the forces in nature and counteracting those forces. A little more thinking results in utilizing current technology and the benefits of nature to achieve the desired results. Humankind has already performed such tasks.

When you see the aftermath of a tornado, you observe what looks like piles of matchsticks – remnants of homes – lying about. They are unrecognizable. Occasionally, you will see trucks, cars or tractors strewn over the landscape. Interestingly, the vehicles are recognizable. What is the difference? The cars and trucks are in *one piece*. Maybe they are dented or with broken windows; maybe upside down or on top of one another. However, they did not break apart. A revised method of construction of homes could allow dwellings an even better outcome than the vehicles. The homes can be more firmly attached to the ground, not enabling them to be tossed around. They can have superior cladding, not allowing any penetration of airborne objects to break through the skin of the structure. Components that withstand this punishment are already available in today's market.

The first argument against the vehicle analogy is that homes are much larger than cars or even large trucks. The second argument is that the cost to reinforce a home to match the structural integrity of a vehicle would be cost prohibitive.

What if a house could be built out of wood and other affordable elements of residential construction to withstand a direct hit from an EF5 tornado or Category Five hurricane? Better yet, what if they could be any design ranging from a mobile home to a luxurious residence of 18,000 square feet or more?

The following pages contain a simple report on the construction of such a life saving solution as well as applications and creative ideas.

CONTENTS

The purpose of this report is to explain various aspects of the proposed hurricane / tornado proof housing system.

This abstract is divided into six categories:

1. Introduction

2. A brief overview of the system.

3. A brief explanation of the principals involved in the design of what I choose to call the “System to Avert Forces Exerted by Hurricanes and Tornadoes”, or Strongbox. Structural calculations will be loosely discussed as well as the criteria for the final solution.

4. Applications of this system.

5. Design solutions to allow greater use of the system.

6. Future developments.

OVERVIEW

The Strongbox system; the name chosen to represent our proposal of a Hurricane and Tornado proof housing system, is a wood system utilizing current technology in the fields of module manufacturing, forged hardware and building trades.

It is lightweight, but more importantly, a proportion, which allows an interior space more familiar with today's housing. Designed to fit in an interior area of 760 square feet with 9'-0" ceilings, the system can be used as a single module or multiple modules. It can, as will be explained later, be incorporated with some conventional construction, allowing the Strongbox to transform its "core" strength to the remainder of the unit. This has benefits especially in the case of tornadoes that can give little warning or worse, when all the occupants are asleep and unable to avoid the damage to themselves or their dwelling as a result of the storm.

Also, the type of structural system used allows for a great number of openings. This is helpful for large windows, doors or passage to adjacent Strongbox units. A "wall of glass" is actually possible in this system.

Another reason for a lightweight, wooden solution is a result of our decision to incorporate this housing system into mobile homes. With an interior area of 760 square feet (the realty and building industries usually incorporate the exterior walls, resulting in an additional 10% square feet to this number). The Strongbox can be made as a single unit, or in multiples; either adding to the length, the width, or both.

PRINCIPALS

The Strongbox utilizes several factory fabricated lightweight wooden modules used in tandem with each adjacent module, then fastened together as a single unit. The unit is designed to be supported on four points only. They would rest on concrete pier foundations, raised concrete pier foundations for storm surge areas (the design of a pier to resist a storm surge is much easier than the design of a building to do the same), or on rails, which are then connected to four piers for mobile home applications.

The first step of the design process involved taking a configuration that seemed to be usable as a living unit. A “box” size was calculated and determined to work the best as a cross between livability and structural efficiency.

Using FEMA guidelines found in their publication: “Design and Construction Guidance for Community Shelters”, FEMA 361 / July 2000, First Edition in conjunction with ASCE 7-98, “Minimum Design Loads for Buildings and Other Structures”, extensive structural calculations were carried out both analyzing the Main Wind Force Resisting System (MWFRS), and Components and Cladding (C&C). The criterion used was events and the highest level for each phenomena: Category Five for Hurricanes and EF-5 for tornadoes

Three-dimensional models were created incorporating the highest wind speed that the system would encounter. In this case, the pressure from the EF-5 tornado's 235 mile per hour wind speed was chosen. These numbers were inputted into the ASCE 7-98 calculations in order to obtain individual forces on each segment of the rectangular living unit.

After calculating the final forces, the main components for the walls, floor and ceiling were designed to resist the forces for MWFRS gained in the previous calculation. The implications of each adjacent component was considered and incorporated in the forces given to each component. Once all of the factors were inputted it was a simple matter of designing the component with known forces. This is a calculation, which is generally incorporated in module fabrication software. However, some diaphragm designs had to be performed longhand.

The final component design netted forces, which would affect the neighboring components. This generated numbers for connections required at each interface of components. Connection details were then designed to transfer these loads. The culmination of gravity and, more importantly, lateral loads were then generated onto four support points which would be given the job of resisting forces in all directions which were given by the weather event..

Connection details were given to transfer these loads onto the concrete piers.

In the case of storm surge locations, the nature, height and size of the piers were designed as well as the underground requirements to resist of force of water at all heights of the above ground portion of the pier in a storm surge situation.

In the case of mobile homes, the connection details to conventional steel rails (easily available train rails were used) from the housing unit, and the connection from the rails to the piers were designed.

The logistics of construction and connecting in a mobile situation had to be “watch dogged” in every

step of the structural design process to allow for not only realistic fabrication, but also realistic transport and attachment ability in the case of the mobile home units.

After the MWFRS was designed, various industry-available cladding and component systems were investigated and tested against our own C&C calculations. The Florida missile test (15 pound 2x2 @ 100 mph) was used as the guideline for all of the components including glazing.

While the wind implications were important, factors such as fire escape capability, ventilation and aesthetics and “green” products and processes had to be a mandatory consideration. This resulted in a set of components and cladding that satisfied all of our parameters.

Additional FEMA guideline factors, such as location and gravity missile loads, were then considered and incorporated into the final unit.

APPLICATIONS

The Strongbox unit can be used in, as mentioned previously, a stand-alone or multiple configuration for both permanent non-movable and movable housing units.

In design examples explained in the following section, the units can be incorporated with additional construction, providing the non-“Strongbox” areas are directly connected to the Strongbox and the components and cladding still meet Florida Test wind conditions.

If circumstances dictate a desire or need for conventional framing (as in the case of a Strongbox being added to an existing residence), the units can be incorporated with conventional framing, providing the following criteria is met:

1. The Strongbox units must be the only places in the home where sleeping and bathing is performed. Framed areas may be allowed to facilitate open living and dining, family play (although media rooms where occupants could feasibly be in a space blocked from sound and light to the exterior; or where the inhabitants could theoretically fall asleep may be deemed unsuitable for conventional construction) garage and storage, and entry foyer and porch spaces.
2. The field-framed portions must still be designed with a continuous load path to resist “normal” wind events (such as the required 90 mile per hour wind loads indicated for the Midwest in ASCE 7-98 and later publications). Also, although the framed components may have to “break away” in a cataclysmic wind event, such as EF-2 tornado or higher, or Category 2 hurricane or higher, the components need to consider not becoming missiles which could endanger those outside at the time of a major storm or those not living in Strongbox housing.
3. Vehicles in framed construction would require tie-downs available for easy connection (not necessarily to be used in every case, but at least able to be connected when a major tornado or hurricane is predicted.)
4. Aesthetics may dictate additions of porches and other accessory structure, but, similar to non-Strongbox framed housing, need to follow the guidelines in criteria 2 of prevention of missiles.

The Strongbox components, when used as multiples, can be designed in many configurations. Four units, for example, can be placed in a square pattern with a square atrium in the center. The units can be also designed to “sprawl” across land, allowing for a “walk through the forest” if the designer should so desire. More design criterion is described in the next section.

DESIGN

A trend shown in the latest architectural journals is very conducive to the “shotgun” design of the Strongbox system. Some designs almost look as if they already incorporate the system.[1] many designs can be generated utilizing only the Strongbox components themselves.

Adding to this is an incorporation of other design philosophies. Considering a housing type, which combines open living spaces in conjunction with more private areas for sleeping and bathing, and, in some cases, kitchen use, allows for some beautiful architecture. A personal favorite of mine is the 1760 Sugarcane Plantation house located in the French Caribbean island of Martinique known as “Pecoul.” The design is typical of homes on this island, with an area, usually a square or rectangle, which is surrounded by a gallery on all four sides. In the case of these homes, the interior is intended to be protected by the second wall of the gallery to keep the occupants safe in the event of a cyclone.[2]

In the case of the intended application for the Strongbox system, the application is very similar, only that the gallery, instead of being shutters directly open to the exterior, making the gallery an indoor/outdoor environment is replaced by a gallery using windows. In the Midwest's severe winters and the South's humidity, today's high tech windows allow for the exterior environment to be pleasantly brought in. This glass gallery surrounds the Strongbox unit in the center, housing the bedrooms and other critical areas.

Also, as a derivative, two bays; one framed and the other utilizing the Strongbox system, can run parallel, giving the same open gallery.

This is only a small portion of the enormous cache of possible designs enabling the Strongbox system to exist in the highly competitive residential market.

1. Metropolis Magazine, May 2007. “Into The Woods” by Edward Keegan. (Design by Brian Johnsen and Sebastian Schmaling)
2. Suzanne Slesin & Stafford Cliff, Jack Berthelot, Martine Gaume and Daniel Rozensztrroch, Photographs by Gilles de Chabaneix, “Caribbean Style”, page 109.

FUTURE DEVELOPMENTS

Further structural analysis of the Strongbox system will net multi-story applications. Since market demand versus cost of construction needs to be considered, the initial product needs to be in the market first. The heavy demands of an EF-5 tornado or Category 5 hurricane requires that the Strongbox needs to be extremely rigid and resistant to extreme torsional forces which would require a design less efficient than the one story plan. Also, the second floor may be a different structural design than the first. However, the benefits of multi-story residential units will eventually outweigh the cost, once recovery from the initial investment of the single story unit is realized.

The Strongbox system can also be incorporated as additions to existing residences; designed on a case-by-case basis. (Zoning requirements may preclude this, in which case some portions of existing dwellings could be deleted in order to install the Strongbox unit.)

Another interesting possibility is the ability for complete modular replacement and reuse. The Strongbox system could be designed as a interchangeable module to be added or removed depending on the current lifestyle of the user. (Obviously there would be some kind of system in place where money would be given for the old unit; payment plans could be in place for ongoing replacement, etcetera.) Modules could be designed for singles, newlyweds, families with young children, etcetera. These units could be shared and reused, allowing the ability to purchase only what one needs at that time. As a result, a lower purchase price for a home could allow more buyers into the marketplace while increasing overall activity. This type of system could affect the entire housing market.