Gulf Coast Hurricane Evacuation: A Case Study of an Inland County's "At-Risk" Shelters

C. Ben Farrow and Paul W. Holley
Auburn University
Auburn, Alabama

It is extremely important to shelter individuals evacuating from hurricane impact areas in safe conditions. Many governmental and non-governmental agencies continue to form new policies to address the temporary, safe sheltering for citizens in the wake of Hurricane Katrina. Many of these plans will direct significant numbers of evacuees to inland communities, possibly placing them at risk. This paper examines the current facilities in one inland county's evacuation shelters. Specifically, an evaluation of twenty-three shelters is made in the event the hurricane tracks inland across the shelter location. The case study utilized a modified evaluation matrix originally developed by the University of Florida in 1997 for shelters expected to receive a direct impact from a hurricane, and also compared survey results to those found in a Louisiana study of similar inland shelters. The results indicate that the shelters currently in use in the county do not meet the standards set forth in the Florida shelter evaluation model. Based on the case study, inland community shelters may be unprepared to withstand impact from a hurricane or other major wind event. Model shelter guidelines for coastal communities are often unrealistic when compared to the facilities that are actually available in inland communities. Further research in this area is needed in order to attempt to match shelter construction parameters with shelter selection and availability.

Key Words: Essential Facilities, Evacuation, Hurricane, Shelter, Wind

Introduction

Hurricanes are a major threat to Gulf Coast communities; these violent storms impact the coastline with extreme winds, storm surges, and torrential rain. As coastal populations increase, the threat of injury and loss of life and property become more significant. In the past two decades alone, storms such as Andrew, Opal, Georges and Katrina caused substantial damage and loss of life on the Gulf Coast.

The increase in coastal populations is also causing evacuation to become a much more complex process. "Using the authority set out in state laws and local ordinances, state and local officials may suggest or require the evacuation of residents from homes and communities before certain catastrophes occur. State laws generally authorize the Governor to order and enforce the evacuation of residents under emergency situations." (Bea, 2005) The evacuation process involves government interaction at many levels, and because decisions in this regard are typically made under the duress of time and the pressure of potential ramifications, the federal government is currently considering integration of policy to provide more concerted procedures. Bea states further that "As members of Congress explore the challenges and losses in the states affected directly or indirectly by Hurricane Katrina, they may be called upon to consider federal policy options to more fully integrate federal and state authorities." (2005)

An increase in propensity for massive evacuations presents significant issues beyond the coast. While inland areas are not typically subject to storm surges, they can still experience the strength of a hurricane's extreme winds and heavy rainfall. According to the National Hurricane Center in Coral Gables, Florida, twenty-five named storms that made landfall on the Gulf Coast between 2002 and 2006 continued inland as a hurricane, tropical storm or tropical depression. Many maintained storm strength for hundreds of miles inland, some with sustained winds between 39mph and 73mph as far as Arkansas and Tennessee. (National Hurricane Center, 2007) This poses threats to all who would evacuate to hotels, friends' homes or similar resources, but specifically endangers a significant part of the population who have medical issues and/or limited income or transportation. This segment of the population would likely seek refuge in or be directed to a designated community shelter within a few hours drive from the coast that could potentially be "at risk" as the hurricane tracks inland.

A dramatic increase in this type of evacuation could, in fact, place many individuals at risk due to inadequacies of the facilities. "Many states have designated schools, community centers or other public facilities as shelters to meet this demand, but these structures were not designed as shelters for extreme wind events." (Coulbourne, McAllister, & Tezak, 2002) Large open rooms and older structures not designed for current wind codes dominate the landscape of many evacuation shelters. Many decision makers do not have the ability to appropriately distinguish between shelters that are "at risk" or "not at risk" of damage from hurricanes or high wind forces.

As Hurricane Opal approached the Gulf Coast in October of 1995, the Santa Rosa Medical Center located in Milton, Florida, evacuated its patients to a nursing home in Andalusia, Alabama. Unfortunately, the nursing home in Andalusia suffered major wind damage from Opal, while the hospital in Santa Rosa was undamaged (U.S. Army Corps of Engineers: Philadelphia District, 1996). In some cases, even inland structures that are purported to be designed to withstand high winds put the public at risk. In 2004, evacuees left the coast of South Florida to be sheltered in a newly constructed community center in Arcadia, Florida. Although no one was killed, the majority of the roof of the center collapsed around the 1,400 people inside as Hurricane Charley moved inland. (Payne, 2004)

Previous Studies to Evaluate Evacuation Shelters

Efforts to this end have occurred in some states, but only in areas within approximately 80 miles of the coast. In 1997, the University of Florida School Of Building Construction and the Florida Division of Emergency Management created a detailed hurricane evacuation shelter evaluation worksheet with 15 categories, a guide, and a summary form that were to be used to assess evacuation shelters in detail in the State of Florida. The document followed the ARC4496 Guidelines for Hurricane Evacuation Shelter Selection produced by the American Red Cross (University of Florida School of Building Construction & Florida Model Hurricane Evacuation Shelter Selection Guidelines Student Manual, 1997). This procedure was used to evaluate shelters across the state of Florida that could likely be subjected to the full effects of a direct impact from a major Hurricane. Shelters not found to be in compliance with the standards were recommended for remedial repair and/or replacement.

Also in 1997, Officials of the Louisiana Office of Emergency Preparedness (LOEP) determined that local jurisdictions were unprepared to shelter residents safely in a hurricane. They initiated a shelter evaluation effort for coastal and proximal parishes that was based on the Florida Hurricane Evacuation Shelter worksheet. The state of Louisiana received $100,000 of financial support from the Federal Emergency Management Agency (FEMA) to complete this assessment (Levitan, Marx, Pine, & Wilkins, 2003).

Evacuation Stakeholders

There are many agencies that provide coordination of shelters in time of disaster, the most notable of which is the American Red Cross (ARC). The ARC is not a government agency, but through its charter from the U.S. Congress in 1905 is obligated to "carry on a system of national and international relief in time of peace and apply the same in mitigating the sufferings caused by pestilence, famine, fire, floods and other great national calamities, and to devise and carry on measures for preventing the same." (American Red Cross, 2007) In providing shelters in times of disasters, the ARC is a primary stakeholder as evacuation policy is analyzed. Like other agencies providing shelter in times of disaster, it is imperative that the Red Cross be able to properly prioritize which buildings are used as evacuation shelters. The selected shelters need to be able to protect those seeking shelter and refuge. Safety of the occupants and risk mitigation for all must be a primary driver in shelter selection.

As evacuation policy continues to be analyzed and formed, the Red Cross and other stakeholders must consider not only the immediate coastal dangers but also the potential for placing evacuees in harm's way inland. Through a case study of one inland county's Red Cross shelters in a Gulf Coast state, this paper considers the potential destinations of the coastal evacuation process. It intends to provide an analysis of the designated hurricane shelters in that inland county. Conscious of the limitations of the ARC's resources, the case study is intended to aid the agency in prioritizing its designated shelters depending on the nature of an impending disaster. It specifically is not an implication that the ARC has a responsibility to utilize only shelters that meet certain criteria.

The assessment of the evacuation shelters was completed during the spring and summer of 2007. The local American Red Cross chapter provided this research project with surveys that they had on file of each shelter. These surveys, the Shelter Facility Survey ARC 6564, were inconsistent and lacked information in regard to the shelters. The survey was several pages long and explored information such as:

- Capacity limits
- The shelter's address
- People to contact at the shelter
- Facility information (parking spaces, facility construction, year of construction, space to note key details of the shelter)
- Safety issues (fire sprinklers, fire extinguishers, fire alarms)
- Utilities (each whether electric, gas, propane, fuel, etc.)
- Sanitation facilities (showers, toilets, sinks)

- Details on accessibility for people with disabilities (curb cuts, ramps, accommodations, seats, grab bars, aisle widths)
- Food preparation capabilities (was a full kitchen available?, number of meals that could be produced, equipment)
- Feeding areas (seating capacity)
- Laundry facilities (number of washers and dryers)
- Health services
- Additional information (such as hazards, shelters proximity to evacuation routes, nuclear power plants, staff required at shelter, etc.)
- An area for recommendations and any other information

Many areas of these original surveys for the county were left blank showing a lack of research into these specific areas. Several of the evacuation Shelter Facility Surveys were also very outdated showing no indication of follow-ups on the current conditions of the shelters as well. Some buildings had been renovated; some had additions that were not recognized beyond the initial documentation. Reasons for the relatively limited information on the forms is not specifically known. The researchers believe that the limited financial resources of the Red Cross coupled with a limited staff and limited knowledge of constructed facilities all contributed to this issue. The limited information of the Red Cross Shelter Facility Surveys confirmed the need for further investigation and proper documentation of the shelters.

Methodology

The county utilized in this case study is considered typical for inland community shelters for hurricane evacuation. Key factors that make the county's location a primary evacuation location are its proximity to the Gulf Coast (three to four hour drive), and its location next to three primary evacuation routes (one interstate highway and two U.S. highways). The county also serves as the dedicated evacuation location for one prominent metropolitan Gulf Coast county. Directives call for the county to prepare to house as many as 4,000 people in the event of a Gulf Coast Hurricane.

Few, if any, inland shelters constructed to the standards developed by the University of Florida model have experienced a design event, making evaluation of these guidelines and standards difficult from a quantitative approach. As a result, a qualitative approach was used for this case study. The model used previously in the states subjected to direct impact was applied to twenty-three shelters in an inland community approximately one hundred fifty miles from the Gulf Coast. The case study is considered relevant and appropriate since other shelter evaluations have used the same metrics when considering shelters subjected to a hurricane.

All twenty-three ARC shelters in the evaluation area were visited and surveyed in order to obtain the necessary information required to make proper assessments. Holding each building to the same standard of assessing it as an evacuation shelter was essential. Also during each shelter's visit, the building owner or manager (whoever was listed as a contact from the shelter) was interviewed to obtain additional information about the building. This interview was scripted and consisted of two pages of questions that examined many different areas of the shelter and

provided a detailed, up-to-date evaluation of the shelters condition. The interview is attached as Appendix A.

The on-site surveys and interviews were conducted by one or more of the following professionals: Structural engineers, Construction professional with four or two-year degrees in Construction Management or Civil Engineering, and persons with extensive experience in the building construction industry. Assessing and prioritizing the evacuation shelters involved "an understanding of storm effects on buildings, common construction techniques, flood risk-assessment methods, construction drawings and specification reading, and structural considerations for storm/hurricane resistance" (University of Florida School of Building Construction & Florida Model Hurricane Evacuation Shelter Selection Guidelines Student Manual, 1997) .

Following the interviews and reviews of existing data for each shelter, the Shelter Facility Surveys were administered and evaluated. A comparison of the results was then made; the Louisiana counties' data was selected primarily because of similarities in its terrain and location away from the coastline and because the State of Florida is primarily peninsular. The only major revision in the evaluation was the removal of concern regarding storm surge, since the case study county was 150 miles inland and at no risk of surge.

Numerous sections of the survey required architectural and structural drawings for verification of the construction systems and the materials in the building. If an evacuation shelter did not have construction drawings of the building, then the worst condition was assumed.

The following specific items were considered as part of the survey:

- Identification (address, contact information, latitude/longitude)
- Rainfall Flooding/Dam Considerations (threat of flooding)
- Hazardous Material and Nuclear Power Plant Considerations (proximity to shelter)
- Lay Down Hazard Exposure (nearby structures or trees that could fall on shelter)
- Wind and Debris Exposure (impact on terrain around building (flat, hilly, etc))
- Wind Design Verification (design stamped by a Professional Engineer)
- Construction Type / Loadpath Verification (definable and continuous flow path for wind induced loads)
- Building Condition / Wind Damage History (overall condition of the building and damage history)
- Exterior Wall Construction (ability to resist wind and impact loads)
- Fenestration and Window Protection (protection of glass in exterior windows)
- Roof Construction / Roof Slope (geometry, weight, type of roof construction)
- Roof Open Span (long open span roofs are known to fail in major hurricanes)
- Roof Drainage / Ponding Information (identify drainage problems/hazards)
- Interior Safe Space
- Life Safety/Emergency Power

As part of the survey's analysis, each facility was classified as "preferred", "marginal" or "non-compliant" on each of the above categories.

Results

The results of the evacuation shelters in the county indicated that there are many subpar evacuation shelters indicated that the American Red Cross currently uses. A summary of the scoring for all shelters is shown in Table 1 below.

Table 1

State of Current "At Risk" Shelters in Case Study County

Number of Shelters for Inland County in Each Scoring Category			
Hazard	**Preferred**	**Marginal**	**Non-compliant**
Flooding	22	0	2
Hazardous Material	19	3	2
Lay-Down	5	15	4
Wind & Debris	1	23	0
Wind Design	2	3	19
Construction Type / Loadpath	4	5	15
Building Condition	16	8	0
Exterior Wall Construction	3	10	11
Fenestration / Window Protection	2	11	11
Roof Construction	0	15	9
Roof Open Span	0	4	20
Roof Drainage / Ponding	15	9	0
Interior Safe Space	0	7	17
Life Safety / Emergency Power	0	24	0

The comparison made with the Louisiana study in the area of "wind design verification" shown in Table 2 below indicates relative similar results for both studies.

Table 2

Comparison of Case Study with Louisiana Assessment

Wind Design Scores Reported in Inland County and Louisiana Assessments				
	Total Shelters Assessed	Highest Scoring Category	Middle Scoring Category	Lowest Scoring Category
Wind Design Verification - Louisiana Survey	73	2	7	64
Wind Design Verification Louisiana Survey (%)		3%	9%	88%

Wind Design Verification Inland County Survey	24	2	3	19
Wind Design Verification Inland County Survey (%)		8%	13%	79%

Authors' Analyses and Conclusions

First, it should be reiterated that the ARC operates on a basis of limited and in many cases volunteered facility resources. The buildings that they use as shelters in times of disaster are typically owned by others, and represent a best effort by the ARC to provide safe haven in accordance with their charter. As an agency that responds on a volunteer basis, the ARC prioritizes medical attention, food and clothing; and in many cases uses buildings that are the only ones available at the time. This analysis in no way purports that the ARC should, or has means to utilize only shelters that could withstand all identified threats, rather is an effort to help them prioritize among available buildings in times of emergency.

Current Facilities

Based on the research, the authors believe that the most critical areas of a survey for any evacuation shelter at risk to hurricanes are "Wind Design Verification," "Flooding Risk" and "Hazardous Material Risk." These issues were deemed especially critical since failure in any one of these areas would subject the occupants to potential disastrous consequences.
The wind design of the evacuation shelters was a very important part of this project. Many buildings did not have construction drawings. Without proper construction drawings the wind design could not be properly evaluated. As noted in Table 1, "Wind Design" data shows that nineteen (19) of the evacuation shelters were "non-compliant" and three (3) evacuation shelters that scored "marginal". This study also had many evacuation shelters that were uncertified buildings with long or open roof spans ("Roof Open Span": 20 "non-compliant" and 4 "marginal"), unreinforced masonry shelters, shelters with flat or lightweight roofs, pre-engineered (steel pre-fabricated) buildings. This type of construction would work fine for a shelter "not at risk" but does not meet the established criteria for shelters that are at-risk in a hurricane event.

Another major problem with the evacuation shelters was the shelter's proximity to hazardous material facilities and the lack of procedures followed for hazardous material facilities relationship to evacuation shelters. Neither the EMA (Emergency Management Agency) nor the local officials had standards as to what was deemed a hazardous material facility. The study established three hazardous facilities based on conversations with local fire marshals and the EMA. As shown in Table 1, two shelters were located within a half mile of a hazardous material facility which resulted in these facilities being rated as non-compliant. This was particularly significant in this study since one of those facilities was the designated as a "special needs facility" where evacuees with disabilities and medical concerns are housed.

For the most part, the evacuation shelters scored well in regard to flooding in the rainfall "Flooding" section with twenty two (22) meeting the "preferred" criteria. However two (2) were classified as "non-compliant" as shown in Table 1. According to FEMA flood maps, two older buildings were within the flood plain or had significant parking areas that were within the flood plain (2007).

Many of the evacuation shelters were very old. Several of the evacuation shelters surveyed were designed and built prior to 1960 when building codes were either non-existent or very limited. Other shelters had no construction drawings available. This was a consistent problem with many churches and recreation centers being utilized as designated shelters. Many times, this was because either the building was very old or the drawings were lost because the building's staff was negligent regarding the importance of the construction drawings. The construction drawings for the schools were located at the school systems headquarters, but not every school had construction drawings on file. The lack of construction drawings led to poor ratings in many cases in evaluating the "Wind Design", "Construction Type / Loadpath", "Exterior Wall Construction", "Roof Construction", and "Interior Safe Space" sections of the survey properly.

The Future of Inland Evacuation

Seek New Shelters

Inland communities should seek new construction completed over the past five years to determine if additional shelters could be obtained. These recent projects would be constructed to current codes, and drawings for each should be readily available for confirmation and record. In an effort to document the design criteria used and confirm that many of the issues required by the survey have been addressed, key stakeholders should obtain stamped construction documents on all buildings used a shelters.

Replacement of Older Shelters

As new buildings are constructed, an attempt should be made to replace some of the older buildings constructed under codes written prior to 1987. These older codes were written without critical information on wind storms that are now fully implemented into the current codes.

Use Current Shelters that have Areas of Refuge for Occupants

Although many of the shelters scored poorly on the overall structure, several of the structures had areas of refuge for building occupants in the event of bad weather. These areas of refuge were essentially interior areas of the building away from exterior windows and doors. Many had walls constructed of reinforced masonry with a heavy ceiling.

This case study was not able to detail all locations of the "areas of refuge". A major hindrance to this issue was that areas of the buildings to be used have not been clearly identified in many of the initial ARC 6654 forms completed by volunteers. In some cases, the shelter spaces appear very isolated and separate from the balance of the facility. In others, it appears that the Red

Cross may use any or all of the facility it requires. A formal evaluation of "areas of refuge" at each shelter area including the number of evacuees that each "area of refuge" could support should be completed and used to establish number of residents each facility may house.

Designing for "At Risk" Shelters

Shelter selection in non-coastal communities cannot be performed under the current ARC guidelines and other published recommendations for "at risk" shelters. This appears to be similar to the results of the Louisiana study. One way to address this issue is to encourage new state buildings, such as schools, to be designed and constructed with designated shelter areas. This approach would provide a safe haven for students during school events and provide critical shelter space for agencies such as the American Red Cross during hurricane evacuations.

Summary

Based on the case study, inland community shelters may be unprepared to withstand impact from a hurricane or other major wind event. An increase in propensity for massive evacuations and model guidelines for evaluation of shelters present an opportunity for stakeholders like this local Red Cross Chapter to rethink shelter selection and prioritization. In addition, this case study indicates that guidelines for coastal communities are often unrealistic when compared to what facilities are actually available in inland communities. Further research in this area is needed in order to attempt to match shelter construction parameters with shelter selection and availability.

References

Bea, K. (2005, September). Disaster Evacuation and Displacement Policy: Issues for Congress. *CRS Report for Congress*, The Library of Congress, Order Code RS22235.

Coulbourne, W.L.; McAllister, T.P.; Tezak, E.S. (2002, June). Design Guidelines for Community Shelters for Extreme Wind Events. *Journal of Architectural Engineering*, 69-77.

(2007, December 10). *Disaster Services* [WWW document]. URL http://www.redcross.org/services/disaster/

Federal Emergency Management Agency. (2007, January 24). *Flood Risks FEMA Flood Zones.* [WWW document]. URL http://www.floodsmart.gov.htm

Levitan, M.L.; Marx, B.D; Pine, J.C.; Wilkens, D. (2003, November). Comprehensive Assessment of Hurricane Shelters: Lessons from Hurricane Georges. *Natural Hazards Review ASCE, 197- 205.*

National Hurrican Center. (2007). *Atlantic, Carribean, Gulf of Mexico Hurricane Track Chart* [WWW document] URL http://www.nhc.gov/tracks (visited 2007, December 10)

Payne, M. (2005, March/April). Disaster Aftermath Designated shelter collapses under winds; flawed design, materials, oversight exposed. *The [Fort Myers, Fla] News-Press*, as referenced by *The IRE Journal*, pp 12-13.

The American Red Cross. (1992, July). *ARC4496 Guidelines for Hurricane Evacuation Shelter Selection.*

The American Red Cross. (2007). *Disaster Services.* [WWW document]. URL http://www.redcross.org/services/disaster/ "(visited 2007, December 10)
University of Florida School of Building Construction & Florida Office of Emergency Management. (1997, October). *State of Florida Model Hurricane Evacuation Shelter Selection Guidelines Student Manual*.

U.S. Army Corps of Engineers: Philadelphia District. (1996, September). *Hurricane Opal Assessment.*

Appendix A

Red Cross Shelter Evaluation

Questionnaire for Building Owner/Manager

Survey Completed by:_____

Date: _____

Information Provided by:_____

Position:_____

Make sure to identify the area of the building in question to the owner. It is unnecessary to discuss sections of the building germane to our evaluation.

1. Do you have construction drawings or documents of the structure that we could review after this discussion? If not, when was the building constructed? If not, do we have any evidence that this building was designed by a professional architect or structural engineer?

2. Does this building have an emergency generator? If so, what elements of the building does it power?

3. Is there a "plug-in" for an emergency generator that would allow a generator to provide power to the facility?

4. Is the roof to the facility readily accessible, and can we view the roof during our visit?

5. When was the roof replaced? Have there been problems with the current roof system?

6. How do the users of the facility refer to the area of the building that is used for evacuation shelter purposes?

7. Is there a history of minor flooding/ponding at the Facility's site under normal rainfall conditions?

8. Have there been any problems with the building or any issues related to the structure of the building that you are aware?

9. What is the primary on-site potable water source?

10. Are there other on-site potable water sources? Non-potable water sources?

11. Is there a survivable on-site septic/sanitary sewage system?

12. What is the on-site sewage system?

13. Is there a kitchen on-site?
    a. What type of food preparation capability does it have?
    b. What types of equipment are available in the kitchen?
    c. How many servings can the kitchen handle per meal?
    d. Is there a cafeteria in the building?
    e. Is there a snack bar in the building?

14. Describe the toilet facilities.

15. What are the size and number of paved/unpaved parking lots on-site?

16. Does the building have any land line telephone(s) that will function even after electrical power is lost?

17. What weather warning communication capabilities are available to the building?

18. Does the building have an intercom system? One way? Two-way? Does the system work when electrical power is lost?

19. What provisions does the building have for dealing with the deaf and blind?