HURRICANES KATRINA AND RITA – LOUISIANA'S RESPONSE AND RECOVERY

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Abstract:

Louisiana's transportation and hurricane protection system took a tremendous blow from two major hurricanes that struck the coast of Louisiana in 2005, hurricanes Katrina and Rita. This presentation will introduce the audience to the transportation infrastructure damage Louisiana experienced as a result of these two storms and will describe how Louisiana is responding to the disasters and our road to recovery.

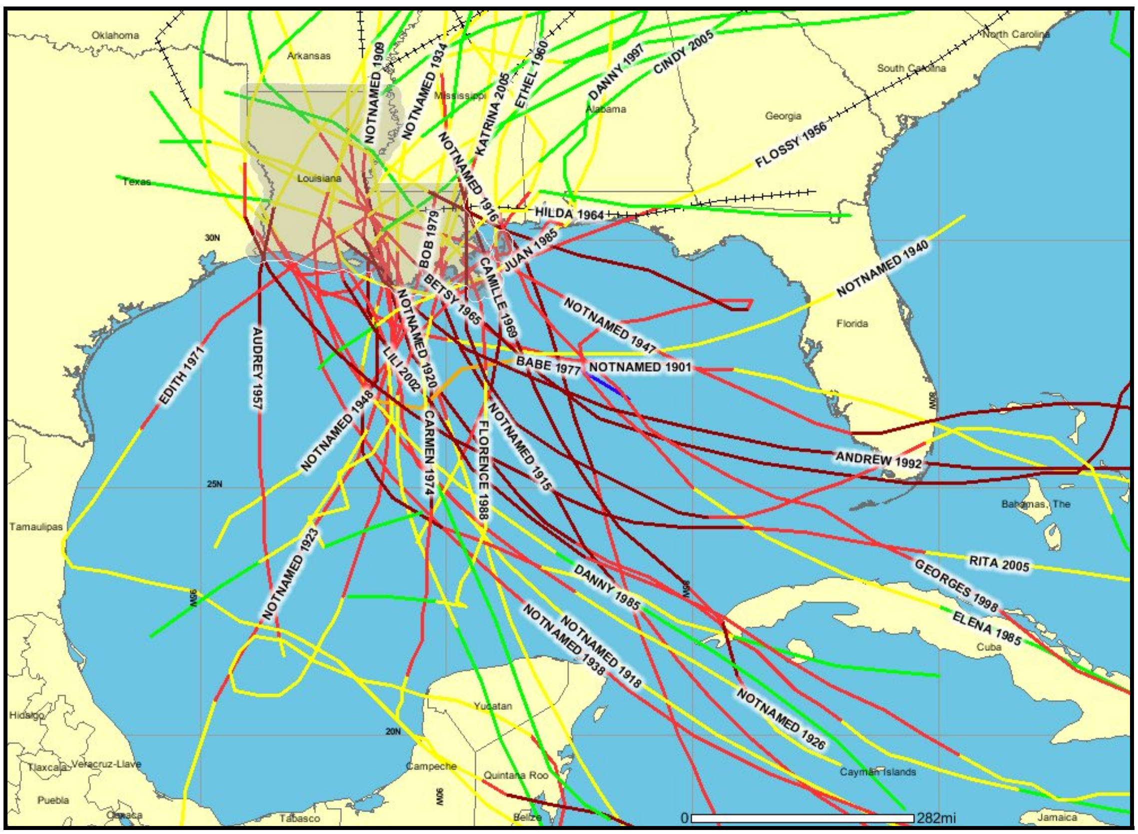

Figure 1 - Hurricanes that hit the coast of Louisiana since 1900

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As Louisiana residents, we become accustom to the ever present threat of hurricanes. Much like other parts of the country, which have other natural disasters such as tornados, mud slides, avalanches or earth quakes, we just prepare for the worst, minimize loss of life and property, and thank God when it is all over. As engineers we know we can always rebuild, but loss of life or livelihood is not replaceable.

2005 STORMS

Figure 2 – Hurricane Katrina

"Hurricane Katrina was the most destructive hurricane to ever strike the U.S."
NOAA

Figure 3 – Hurricane Rita

"*Hurricane Rita was the third most intense hurricane ever in the Atlantic Basin behind Hurricane Gilbert in 1988 and the 1935 Labor Day Hurricane…"*

NOAA

Hurricane Katrina was a category 4 storm when it made landfall on August 29, 2005 along the Louisiana – Mississippi Gulf Coast. The storm was a fast moving storm and provided minimum time for preparation. Refer to figure 2.

Just as we were getting back on our feet from the impacts of Hurricane Katrina, BAM! We were faced with another storm, Rita. Hurricane Rita struck the Texas – Louisiana Gulf Coast on September 24, 2005. Hurricane Rita was a Category 3 Storm when it made landfall.

Everyone has an opinion about Louisiana and how it reacted to the storms, we did some things right and some things wrong. The one thing you can be sure of, we were doing the best we could under the extreme circumstances. In the history of this country there has never been such a natural disaster spread out over such a large geographic area. According to FEMA, over 650 square miles of area in Louisiana were flooded during hurricane Katrina, and much of the New Orleans area stayed under water for weeks after the storm. This was new territory for Louisiana's government and also for the Federal government. We must be careful to have achievable expectations with respect to governmental response to these types of natural disasters. Mobilizing response efforts take time and resources. My observations during the assessment period after the storms were that the governments, both State and Federal had a considerable presence on the ground, but were disconnected because of communication issues. When you are on a roof top in a flooded area, any delay in rescue is too long.

The LaDOTD, Louisiana Department of Transportation and Development, Bridge Design Section in concert with the Federal Highway Administration participated on the bridge assessment teams that went into these areas. The two storms were distinctly different. When we went into the Western parishes of Louisiana after Hurricane Rita, a couple of days after the storm, people were cleaning up and making plans for rebuilding, much like the Mississippi Gulf Coast. Sure the area was devastated, all essential life supporting infrastructure was destroyed, but people could get in to the damaged areas and no major search and rescue effort was required. On the contrary with Hurricane Katrina, much of Orleans, St. Bernard and Plaquemine parishes were inaccessible without special equipment such as helicopters or boats.

PREPARING FOR THE STORM

We can not control the Hurricane, the course it will take, the damage we will sustain, or how it will affect our state. But what we can control is taking appropriate actions on the local level to minimize damage to infrastructure and loss of life, providing the public with up to date information to make informed decisions, assisting the disabled or disadvantaged in evacuation and utilizing good evacuation techniques. How we prepare for the recovery effort is one of the most important pre-storm activities and will enable the post-hurricane responses.

Prior to the storm there are several things that our Districts will do to prepare for pre-storm and post-storm recovery activities. A few of these activities are as follows:

- Set up all communications with Police, Office of emergency preparedness, Civil Defense, and other LaDOTD Districts.
- Inventory signs for "High Water", "Road Closed", variable message signs, "Evacuation" and other advisory signs in preparation for post – storm activities.
- Align personnel that will be available post - storm to begin recovery efforts.
- Refuel all units, maintenance yards and movable bridges to assure maximum available fuel for recovery efforts and alternate power supply.
- Staging essential equipment to make sure equipment necessary for recovery is not flooded and damaged by the storm. If equipment is staged properly, the recovery efforts can be established on several fronts allowing for quicker debris removal and access to damaged areas for assessment.
- Move all ferries to safe harbor.
- Remove traffic gates from movable bridges as time permits in order to prevent loss of these traffic control devices.
- Organize assessment teams and meet to develop post – hurricane strategies.
- Institute evacuation procedures at the appropriate time based on immanent landfall of a storm.

EVACUATION

Over 65% of Louisiana's population lives within 50 miles of the Gulf Coast. According to the 2000 census that is approximately 2 million people. Accurate forecast of the path of the storm and effective evacuation is essential. Louisiana and the Gulf Coast states have developed a very effective evacuation plan. But even the perfect plan is subject to people taking the advice of the government and evacuating these areas that will be hard hit.

The Gulf Coast areas utilize an evacuation method referred to as contraflow. We institute an operation of the major routes where by we direct all traffic away from the major populated areas except for emergency vehicles, allowing for the movement of large volumes of traffic away from the potential landfall of the storm.

Contraflow procedures are set up to evacuate coastal areas in phases to minimize congestion on highways and produce a consistent flow of traffic away from these vulnerable areas. As you can see in the figure 4, the phases are based on the relative location to the coast.

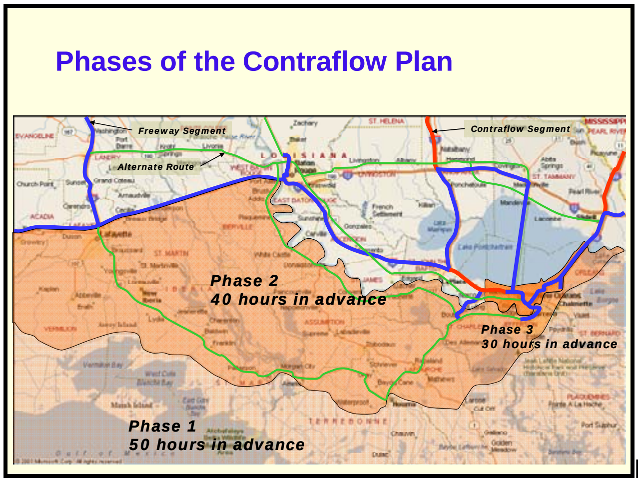

Figure 4 – LaDOTD Contraflow Plan

The timeline for activating contraflow activities are as follows:

- 72 hours before landfall – stage traffic control
- 60 hours before landfall – crews on standby
- 48 hours before landfall – implement Phase 1 evacuation
- 36 hours before landfall – implement contraflow
- 12 hours before landfall – discontinue contraflow

Figure 5 – LaDOTD Contraflow Plan

The contraflow plan for Hurricane Katrina was very successful. Our contraflow techniques were so successful that other state such as Florida and Texas are studying our model to determine how this may be used in their states. Contraflow activities were in operation for 25 hours and approximately 1 million people were evacuated from the potential landfall area.

INFRASTRUCTURE DAMAGE

Bridge structures in general are very resilient to hurricane damage with the exception of open water bridges, such as those in Lake Pontchartrain. My experience with assessment of bridges across coastal Louisiana is reported in the following categories, fixed bridges, movable bridges, and open water bridges.

FIXED BRIDGES

The major damage that we experienced with fixed bridges was associated with debris, abutment scour, undermining of approach slabs and in some cases, pier scour. Most of these problems can be temporarily resolved quickly to establish essential transportation routes. Usually permanent repairs are performed on an as needed basis after essential routes are re-opened to recovery operations.

Abutment scour and undermining of approach slabs essentially close bridges to traffic, however this is one of the easiest damages to correct. The following pictures depict typical bridge end damage. The portion of the approach slab to the left of the light stand does not have any soil to support it after the storm.

Figure 6 – Causeway Bridge Abutment Scour

Figure 7 – Abutment and Approach Slab Repair

Temporary repairs are usually accomplished through demolition of the approach slab, installation of premixed base course material and a roadway aggregate surface. The bridge can then be reopened to traffic. If the approach slab only has minor undermining, the soil support is re-established through mud jacking. The key to these types of recovery efforts is to have contractors and materials lined up prior to landfall of the hurricane.

During these extreme events, most contractors will go above and beyond the call of duty to assist the state in re-establishing transportation routes. This type of partnership benefits the states recovery tremendously.

Figure 8 – Debris

Sometimes debris build up on our bridges can be extensive. Figure 8 demonstrates one of the largest debris piles on any bridge we encountered during our bridge assessments. There is a large harbor facility for the seafood industry near this bridge site. A large number of the vessels stored at this site landed on the bridge approaches. The US Coast Guard assisted with the removal of some of the larger vessels.

MOVABLE BRDIGES

Movable bridges are much more susceptible to damage from hurricanes. By design, movable bridges are usually low bridges and close to the water surface elevations. These bridges are usually utilized in areas where there are navigational needs, but only a small structural foot print is acceptable.

We have 152 movable bridges in Louisiana and 142 of these bridges reside in the area affected by these two storms. Of the 142 bridges, 52 sustained damage and 1 is still closed today.

Since movable bridges by design are near water surface elevations, these bridges are usually inundated during extreme events. Some of the damages that can be expected are displayed in figures 11 – 16.

Debris buildup on structures is a big problem after a storm. Debris must be removed in order to properly assess the damage to the structure.

Figure 9 – Debris Buildup

Figure 10 – Inundation of Swing Span Bridges

Figure 11– Removal and Reconditioning of the Pivot Bearing

When swing span bridges are inundated the pivot bearing must be jacked, inspected, cleaned and reconditioned prior to operation of the bridge. In some instances after Hurricane Katrina, bridges were opened to marine vessels allowing work forces passage into the New Orleans area for dewatering the city prior to the Department reconditioning these bearings.

Figure 12 – Destroyed Generator

Alternate power supplies for movable bridges are particularly susceptible to storm surge and often lost or damaged during hurricane events. Generators are usually placed close to grade for ease of access and servicing. In some installations these units were elevated above the storm surge elevation and survived the storm. A storm hardening of these installations is a good design improvement that should be considered.

Figure 13 – Electrical Systems

Electrical systems as shown in figure 13 usually require full replacement after inundation with salt water.

Figure 14 – Droop Cables on Vertical Lift Bridges

Droop cables are aerial electrical and communication cables that connect the towers on vertical lift bridges. In many cases, droop cables sustained wind damage. These cables were twisted and sometimes pulled form the service box. When these cables are damaged they must be replaced for safety and operational reasons.

Figure 15 – Pier Protection Systems

In several instances, pier protection systems sustained damage from storm surge. In figure 15 the pivot pier protection system is severely damaged and the rest pier protection systems are missing.

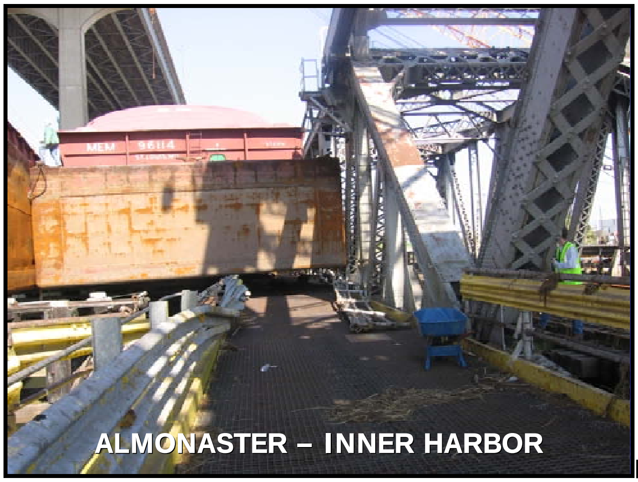

Figure 16 – Debris on Structures

When a bridge resides in an industrial area, often floating barges break free and drift with the storm surge until they meet up with a bridge structure and come to rest. In figure 16 two such barges came to rest on the cantilevered roadway and fender system of this bascule bridge on the inner harbor navigational canal.

OPEN WATER BRIDGES

Over the past few years we have seen more instances of damage of bridges which span over the open water in coastal zones. Florida, Mississippi and Louisiana have all sustained extensive damage to their bridge infrastructure over the open water in coastal zones. Because of this problem the FHWA is coordinating a Pooled Fund Study and research efforts to assist in the development of AASHTO design specifications for coastal bridges.

Figure – 17 Lake Pontchartrain Bridges

Open water bridges are particularly susceptible to damage from storm surge and wave action. The damage to the I-10 Twin Span Bridges across Lake Pontchartrain are good examples of the vulnerability of these types of structures. When the water surface elevation due to storm surge, tides and wind reaches an elevation just below the low chord of the structure and remain there for an extended period of time, wave forces continuously impact the structure. Wave forces have two components, a vertical impulse force acting on the bottom of the structure from the rolling motion of the wave and the horizontal force from the forward motion of the wave. Refer to figure 18 for illustration and order of magnitude of these loads.

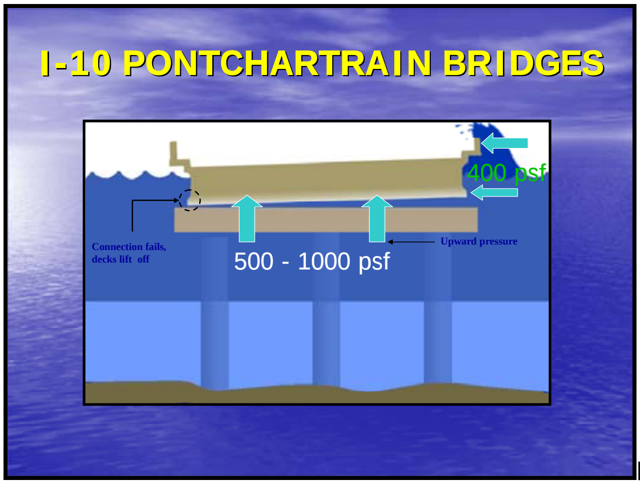

Figure 18 – Wave forces

In the case of the I-10 bridges, the bridge bearings failed due to continuous wave forces acting on the structure and then the waves lifted and pushed the structure off of its supports. We were very fortunate that many of the spans were temporarily restrained by the substructure risers for a sufficient length of time to allow the water to recede before these spans fell into the water. Wave forces applied transverse to the structure, moved spans uniformly transversely and in many cases they fell off of the ends of the caps. Refer to figures 19. Waves acting diagonally to the structure place enough drag on the superstructure to displace the substructure and the spans simply fell off of the sides of the caps. Refer to figures 20 and 21.

Figure 19 – Damage due to transverse wave action


Figure 20 – Damage due to diagonal wave action


Figure 21 – Damage due to wave action

The I-10 Twin Span structure is composed of 5.4 miles of twin structures. The spans are 65' monolithic simple prestress girder spans on 54" diameter precast prestressed concrete cylinder piles. These structures were constructed utilizing some of the early accelerated construction techniques.

The damage to the I-10 Twin Span structures was extensive. Sixty four of the spans were totally lost and four hundred and seventy three spans were displaced laterally one girder spacing. Over fourteen thousand feet of bridge railing was damaged.

If superstructure elements are not adequately connected to the substructure, then the superstructure connection simply fails and the superstructure is washed off of the supporting elements by the wave forces. However, if the superstructure is rigidly attached, the superstructure elements must be designed to resist the wave forces. This presents a design challenge since many of the superstructure elements are designed to resist forces acting in a different direction than the wave forces act, such as prestressed concrete girder elements.

In figure 22, it is evident that the attachment of the superstructure to substructure was marginal and the bridge sustained severe damage to the ends of the concrete girders. This provided a difficult situation during the emergency repair, since we could no longer depend on these ends for support. In many cases support was re-established away from the damaged area. These girder ends are one of the reasons the structure could not be salvaged. Any spans that were completely removed from the substructure were deemed un-salvageable. This lesson was learned from Escambia Bay project.


Figure 22 – Damage to girder ends


Figure 23 – Damage to bridge railing

In figure 23, it can be seen that earlier designs of bridge rails did not consider loads that may act on the back side of bridge rails, opposite to the primary traffic loading. Because of these types of design large sections of bridge rail must be replaced because of severe damage from the storms.

RESPONSE AND RECOVERY

Louisiana is bouncing back from the storm. The I-10 Twin Span Bridges were repaired in just approximately 4 ½ months. The first bridge structure was reopened to traffic just 45 days after Katina made landfall. This was in part from the cooperation and help of the Florida DOT which provided information on what was learned from the Escambia Bay Project.

The Louisiana Legislature mandated change in the way Louisiana government was structured to oversee hurricane and coastal protection. Some of these changes are as follows:

1. Coastal Protection and Restoration Authority
   - Places responsibility for the direction and development of the state's comprehensive master coastal protection plan within the office of the governor
   - Provides state leadership and direction in the development and implementation of policies, plans and programs for comprehensive coastal protection
   - Combines and unifies hurricane protection and coastal restoration efforts
   - Coordinates local, state and federal efforts to protect Louisiana's coastline

2. Regional Flood Protection

- Reorganized the governance and structure of the Levee Boards into two geographic basins, Southeast Louisiana Flood Protection Authority – East and Southeast Louisiana Flood Protection Authority – West.

3. Hurricane Flood Protection in LaDOTD
   - Reorganizes DOTD's Office of Public Works into the Office of Public Works, Hurricane Flood Protection and Intermodal Transportation
   - Authorizes the Office to administer all matters relating to engineering, design, construction, extension, improvement, repair and regulation of hurricane flood protection systems
   - Creates a Hurricane Flood Protection Advisory Commission
   - Creates the Hurricane Flood Protection, Construction, and Development Priority Program
   - Authorizes the Office to establish maintenance, repair and inspection program

The LaDOTD is also pursuing funding for roadways damaged by prolonged inundation in the New Orleans area as a result of Hurricane Katrina. There were approximately 2000 miles of roadway in the New Orleans area that were inundated for more than 5 weeks. Damage to these roadways will not show up until a later date, after the time period required for federal participation. Much of the damage will be a result of the extensive use it will receive during the rebuilding of the New Orleans area.

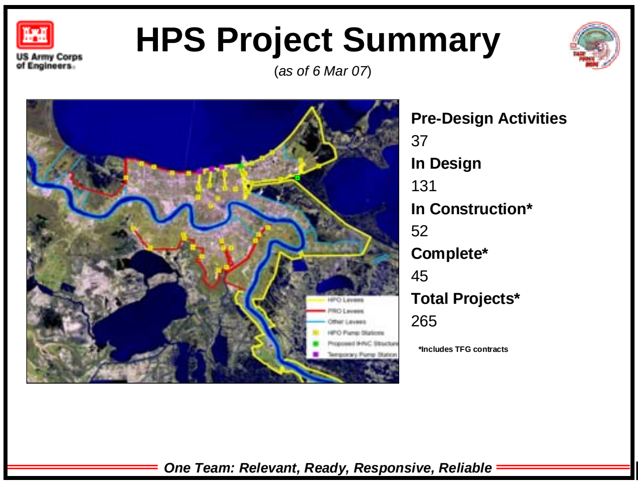

Figure 24 – On going USACE Levee Projects

Many of the US Army Corp of Engineers' projects are progressing well. Refer to figure 24 for details.

CONCLUSIONS

Louisiana has taken a devastating blow by the two major hurricanes of 2005. Much like other coastal states we are rebuilding and improving our ability to react to natural disasters. We would like to believe that residents are getting more educated about the effects of these storms and more willing to evacuate when required. We always learn more from our mistakes, than we do from our successes. Much like the events surrounding the hurricanes of 2005, you can never really anticipate or plan for this type of disaster, until you have experienced one and documented your lessons learned. Perhaps our lessons learned by these events will aid the federal and local governments to be better equipped and ready to respond to the next victims of this type of natural disaster.

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US Army Corp of Engineers