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U.S. Department of Transportation
Federal Highway Administration

U.S. DOT Gulf Coast Study, Phase 2

Engineering Case Study 6: Road Alignment Exposure to Storm Surge

This is one of 11 engineering case studies conducted under the Gulf Coast, Phase 2 Project. This case study considered the potential impacts of coastal storm surge on a segment of I-10 bordering the Oakdale neighborhood in southern Mobile.

Description of the Site and Facility

This case study looked at the potential for a major highway to overtop during a storm surge event, as well as the potential flooding impacts on the surrounding community due to storm surge passing through the highway underpasses.

I-10 traverses Mobile and Baldwin Counties and is a critical route for traffic crossing Mobile Bay; it also serves as a throughway between New Orleans and Florida. This case study looked at the segment between mileposts 24 and 25, because there is a well-defined low point to the highway as well as three bridges with underpasses that storm surge flooding could potentially pass through and flood the surrounding community.

In this segment, I-10 is a 10-lane freeway that is offset approximately 1,000 to 2,000 feet (305 to 610 meters) from the shoreline of Garrows Bend, an estuary within Mobile Bay. Surrounding land uses include the residential neighborhood of Oakdale to the north and west of the road and industrial facilities located to the east, between the roadway and the shoreline.

Climate Stressors and Scenarios Evaluated and Impacts on the Facility

The following three storm surge scenarios were considered for this adaptation assessment:

- Hurricane Katrina Base Case Scenario: This scenario represents the surge conditions that actually occurred in Mobile during Hurricane Katrina.
- Hurricane Katrina Shifted Scenario: This scenario estimates the surge levels that could have occurred if Hurricane Katrina's path was shifted east to make landfall directly in Mobile.
- Hurricane Katrina Shifted + Intensified + Sea Level Rise (SLR) Scenario: This scenario estimates the surge levels that would occur if Hurricane Katrina made landfill directly on Mobile, intensified with stronger winds, and came on top of 2.5 feet (0.8 meters) of sea level rise.

For each of these storm surge scenarios, the performance of the facility was evaluated based on:

- Whether the I-10 roadway and underpasses could be overtopped or flooded by the surge
- Whether the I-10 roadway embankment could be breached due to overtopping

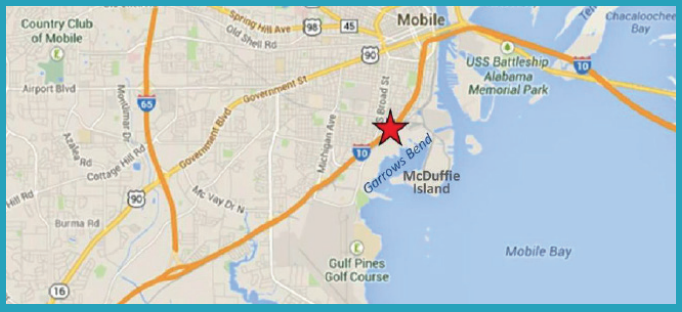

Figure 1: Location of the I-10 segment

Figure 2: Underpass at the I-10 segment

- Whether the Oakdale neighborhood could be flooded due to water passing through the underpasses
- The implications of flow velocities passing through the underpasses

The results of the analysis for each of these impacts are shown in Table 1.

<table>
<tr><th>Scenario</th><th>Roadway Overtopped?</th><th>Roadway Breached?</th><th>Oakdale Neighborhood Flooded?</th><th>Implications of Flow Velocities?</th></tr>
<tr><td>Hurricane Katrina Base Case</td><td>Overtopped only at one roadway underpass</td><td>No</td><td>A small portion of the Oakdale neighborhood would be inundated, roughly equivalent to the area within the 100-year flood zone</td><td rowspan="3">All three bridge crossings, made of concrete, should be able to withstand the flow velocities. However, sections of the medians that contain soil and grass could be subject to erosion. This may be of concern since the bridge piers are located in the grass medians, as is a rail line.</td></tr>
<tr><td>Hurricane Katrina Shifted Scenario</td><td rowspan="2">Overtopped at I-10 roadway and all three roadway underpasses</td><td>Surge would erode 60 feet (18.3 meters) into both the inland and seaside embankments, causing failure of the shoulder lane and four travel lanes on both sides of the roadway</td><td rowspan="2">More significant flooding that encompasses large portions of the neighborhood would occur</td></tr>
<tr><td>Hurricane Katrina Shifted + Intensified + Sea Level Rise Scenario</td><td>Surge would erode 114 feet (34.7 meters) into both the inland and seaside embankments, which would result in breaching of the entire width of the roadway</td></tr>
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Table 1: Performance of Roadway under Storm Surge Scenarios

Identification and Evaluation of Adaptation Options

Four adaptation measures were evaluated, as shown in Table 2. These measures focused on protecting the embankment and underpasses from erosive flows, and preventing overtopping of the roadway. However, these options would not prevent water from flowing through the underpasses, meaning the extent of flooding in the community would not be mitigated. Adaptation options that would prevent water flowing through the underpasses (essentially using I-10 for the purpose protecting the Oakdale neighborhood) were not assessed; I-10 was not intended, nor designed, for this purpose.

Potential Course of Action

To select the appropriate course of action, a cost-benefit analysis would need to be conducted. All adaptation options offer different amounts of protection, but are also associated with different costs. For example, Option 1 is the lowest cost option, but provides only limited protection. Option 4 would sufficiently protect against erosion under all surge scenarios, and could do so at lower cost and with less traffic disruption than Option 3, but the roadway could still be overtopped. Only raising the roadway could prevent overtopping; however, it is unclear whether the additional benefits of raising the roadway (mainly, continued access to the roadway during the event) would outweigh the costs of doing so.

Adaptation Option	Description	Conclusions
Option 1: Harden the two underpasses exposed under Hurricane Katrina Base Case scenario	Harden grassed areas within underpasses with concrete to protect against erosive flow of the surge. Also convert ballasted railroad track to a direct-fixation track, which is resistant to erosive flow.	Lowest cost option considered. Sufficient for protecting the two exposed underpasses against erosive forces under the Katrina Base Case scenario, but would not offer sufficient protection under the other scenarios.
Option 2: Harden all underpasses and raise I-10 to 21 feet (6.4 m)	In addition to hardening the underpasses, raise the low point of the road by 6.4 ft (2 meters).	Would prevent overtopping of the roadway during the Hurricane Katrina Shifted scenario, and also protect the embankment from erosive flows. Does not offer sufficient protection under the Katrina Shifted + Intensified + SLR scenario.
Option 3: Harden all underpasses and raise I-10 to 26 feet (7.9 m)	In addition to hardening the underpasses, raise the low point of the road by 11.4 ft (3.5 meters).	Would prevent overtopping of the roadway during a Hurricane Katrina Shifted + Intensified + SLR scenario, and also protect the embankment from erosive flows.
Option 4: Harden all underpasses and armor roadway embankment	In addition to hardening the underpasses, armor both sides of the embankment with vegetated, permanent reinforcement matting.	Would protect against erosive forces of the Hurricane Katrina Shifted + Intensified + SLR scenario at a lower cost and with less traffic disruption than raising the underpass. However, roadway could still be overtopped.

Table 2: Potential Adaptation Measures

Lessons Learned

Research is lacking on the topic of embankment breaching. Many studies have aimed to establish estimates of flow rates and breach dimensions for earthen dams and levees, but not many have developed methods to predict the onset of embankment breaching, or focus on highway embankments. This is an area of future research that would be needed in order to more accurately predict the impact of storm surge flooding on highway embankments.

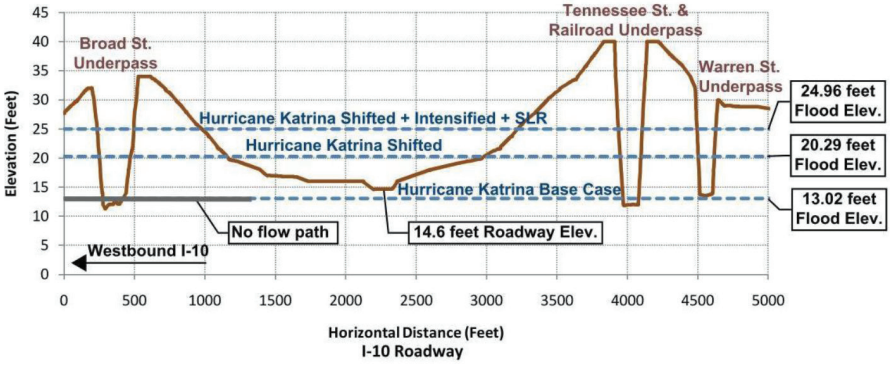

Figure 3: Elevation Views of the I-10 Study Segment Roadway Profile and Underpass Cross-Sections

Figure 4: Hurricane Katrina Shifted + Intensified+ SLR Flood Zone in the Vicinity of the I-10 Study Segment, Flood Elevation 25 Feet (7.6 Meters)

For More Information

Resources:

Gulf Coast Study:
Engineering Assessments of Climate Change Impacts and Adaptation Measures

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