FHWA-HEP-15-019

U.S. Department of Transportation
Federal Highway Administration

U.S. DOT Gulf Coast Study, Phase 2

Engineering Case Study 7: Coastal Tunnel Exposure to Storm Surge

This is one of 11 engineering case studies conducted under the Gulf Coast, Phase 2 Project. This case study focuses on the vulnerability of a coastal tunnel to storm surge. This engineering assessment was adapted from the Storm Surge Analysis for the I-10 Tunnel study conducted by Douglass et al. (2007).[1]

Description of the Site and Facility

The I-10 Tunnel (also known as the George C. Wallace Tunnel) is located at the west end of an elevated causeway across the north end of Mobile Bay (see Figure 2) and carries significant levels of traffic under the Mobile Ship Channel (the Mobile River). This case study looks at whether, without considering sea level rise, a hurricane storm surge could cause tunnel flooding due to surge entering the tunnel entrances (see Figure 1).

At the time of this study, the FEMA flood maps for the area were over 25 years old, and recent updates in a neighboring county had drastically increased the estimated flood levels. Thus, there was concern that hurricane storm surge extents could be much more severe than indicated on the existing maps.

Climate Stressors and Scenarios Evaluated and Impacts on the Facility

The Douglas et al. study evaluated the vulnerability of the tunnel to current climate extreme events; it did not specifically consider climate change scenarios. Rather, it re-evaluated the relationship between storm risk and storm surge for the 25-, 50-, 75-, 100-, 150-, and 200-year storm return period, using a three step modeling process developed by the U.S. Army Corp of Engineers (USACE) and the Federal Emergency Management Agency (FEMA) for coastal flood analysis and mapping.

1. The ADvanced CIRCulation model (ADCIRC) was used to obtain coastal storm surge by simulating all storms that significantly impacted the study area since 1886 and, in order to include the most severe possible events, simulated shifted storms with direct landfall in Mobile.

2. The ADCIRC computed surges were used as input to the Empirical Simulation Technique (EST) model to develop the storm surge–frequency relationship (i.e., storm return period).

3. A combination of a weir[2] flow model and EurOtop, a wave overtopping model, was used to produce flood hydrographs to obtain the storm surge elevations.

The analysis found that the peak 100-year storm surge elevation is three to four feet (0.9 to 1.2 meters) higher than the existing FEMA maps. Additionally, the existing tunnel could experience some flooding during a 75-year return

1 Douglass, S., N.W. Scheffner, and Kellogg Brown & Root Services, Inc. 2007. Storm Surge Analysis Report for the I-10 Tunnel. Project No. ST-049-000-004, I-10 Tunnel Flood Mitigation. Kellogg Brown & Root, Inc. Report to Alabama Department of Transportation.

2 A weir is a barrier across a river (smaller than a dam) characterized by the allowance of water to flow over the top of the barrier.

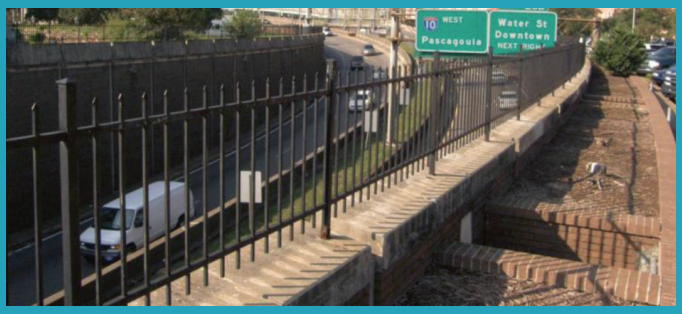

Figure 1: West Portal of the I-10 Tunnel

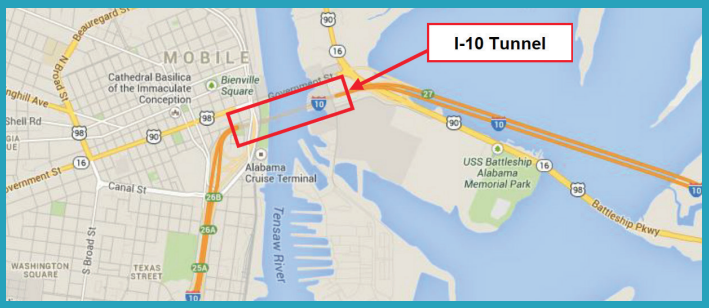

Figure 2: Location of I-10 Tunnel

period storm (a 1.3% chance of occurrence in any given year) and full flooding under a 100-year return period storm (1.0% chance of occurrence in any given year).

Identification and Evaluation of Adaptation Options

The analysis identified three potential adaptation options, as shown in Table 1.

While the cost effectiveness of these adaptation options was not evaluated, there are some important broader considerations associated with each option. For example:

- Location: The west tunnel portal is adjacent to historically significant buildings which presents technical challenges for geotechnical and structural engineering.
- Traffic: Due to traffic congestion, Mobile is also considering constructing a bridge at this location.
- Criticality: The tunnel is heavily used and closing the tunnel with temporary flood gates would need to be done before the peak of the storm, affecting tunnel users that would include emergency services.

Potential Course of Action

The following monitoring activities should be undertaken:

- Installing a recording tidal gauge
- Establishing a log to record the details and dates of any climate stressor-related incident, and the performance of the tunnel
- Noting updates of sea level projections such as those provided by the U.S. Army Corps of Engineers

Lessons Learned

Use of the most commonly understood measure of storm strength, the Saffir-Simpson Hurricane "Category" Scale, is not particularly valuable for engineering decisions related to storm surge as there is not a one-to-one relationship between storm surge and storm "category."

Integrating vulnerability into decision-making will typically include some iteration or "feedback-loop" process such as the search for more effective alternative design options.

Measure	Description	Conclusions
Raise the elevation of the west portal wall	Raise the west portal wall to match the elevation of the east portal wall (19 feet, 5.8 meters) to increase flood protection.	Provides only limited flooding protection for the 100-yr event with full flooding occurring for the 150-year event, because wave overtopping will occur at the more exposed east portal.
Raise all approach walls and construct a berm	Raise all approach walls to 19 feet (5.8 meters) and construct a berm/ seawall around the east portal to reduce wave overtopping.	No flooding for all scenarios up to the 150-year event. Takes advantage of site specific geological characteristics. Elevated tunnel approach is still vulnerable to damage.
Install temporary flood gates	Install temporary flood gates to completely seal the tunnel before the storm hit.	Would protect the tunnel from all storms including the 500-year event. Significant operational issues related to closing an interstate highway during hurricane approach would result.

Table 1: Potential Adaptation Measures

Selection of appropriate storm surge and wave computer models should be undertaken by experienced coastal engineers who know how to quantify risk from storm surge, know the physical processes and damage mechanisms to look at, and which models will give the most accurate results.

Seemingly logical design options may not effectively achieve the primary goal; increasing the portal wall elevation just to account for storm surge alone would not have increased the level of flood protection by much. Wave impacts on top of the surge are important in this coastal situation because of wave overtopping at the more exposed portal.

For More Information

Resources:

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

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