Six Mass Flood Events in Thirteen Months – ’15 and ’16

- Memorial Day 2015
- Halloween 2015
- Memorial Day 2016
- Full Pool
- And Then Came Harvey…
  - Tropical Storm Allison was previous benchmark for highest rain totals in Texas.
  - Hurricane Harvey dwarfed the Allison numbers and set the record for the highest rain total in the Continental United States.
  - After making landfall and moving away from Corpus Christi, forward movement slowed and Harvey stalled over Southeast Texas (Houston and Beaumont).

Bridge Evaluations – Don’t Get Ahead of Yourself

- Weather events can shift dramatically from predictions (especially hurricanes).
- Often little to accomplish by responding while event is ongoing
  - Maintenance personnel must check roadways and bridges, but...
  - Often little that can be evaluated.
  - Focus on identifying critical structures.
- Be prepared as soon as water recedes.

Scour is the Exception

- Scour is most likely cause of catastrophic collapse (though debris impact is a pretty close second).
- Identify scour-critical bridges and evaluate as soon as you can safely do so.
- Evaluating for scour:
  - Weighted tapes, probes, and gauges work very well for rapid assessments.
  - Depth gauges (we call them shi-flos, which is a fancy word for a fish finder attached to a water ski) are more accurate, especially if there is a fast-moving current.
  - Underwater Imaging/Side-Scan Sonar.

Measuring for Scour – Simple but Effective
Depth-Gauge (or Shi-Flo, in Texan)

Depth gauges are effective with fast-flowing current.

Go-kits with all the necessary equipment were extremely valuable.

Underwater Imaging/Side Scan Sonar

Truss Bridge at Sabine River

Underwater Imaging/Side Scan Sonar

Underwater Imaging/Side Scan Sonar
Now the Hard Part – Which Ones are Actually Scour Critical?

- It is essential to have a statewide set of criteria for determining scour criticality.
- Tendency is to be on the safe side and call a bridge “scour critical.”
- Overly-conservative determinations can lead to unnecessarily long lists of “critical” structures that are not actually at risk.
- Getting a long list of bridges, many of them not actually critical, makes it very difficult to pinpoint and prioritize those that really are at risk. Not a good thing in the midst of an emergency response.

Flash Flooding vs. Slow Rise

- The seven extreme flooding events in the past three years have demonstrated how different the scour events can be depending on geography.
- Since a large portion of Texas bridges are in clay soils, scour depends upon the length of time the flow exceeds a certain level.
  - In the rocky and steep hill country (e.g. Central Texas), the water levels rise and fall quickly. Scour is often not significant.
  - Along the coastal, flat areas (e.g. Southeast Texas) the rise and fall of the water is more gradual and takes a longer period of time. Scour and bank erosion are typically more significant in this region.
- In both cases debris is a major problem.
  - For flash flooding, large debris traveling at a high speed can severely damage bridge components.
  - For slower water, debris can completely clog hydraulic openings, forcing the channel to move and often resulting in severe erosion at approach spans and roadways.

Memorial Day 2015 Flash Flooding

Yet there wasn’t much scour associated with the flash flooding even where the bridges suffered catastrophic collapse. The Blanco River rose so rapidly that the bridges were overtopped quickly and then water dropped rapidly, so there wasn’t sufficient time for scour to develop in the clay soils.
Harvey Flooding in Houston

From: http://mb.ntd.tv/2017/08/30/harvey-swamps-evacuee-shelter-on-texas-louisiana-border/

Harvey Slow Rise – Copious Amounts of Water

Relief structure at Interstate near Houston. The frontage road was inundated, and extensive scour occurred at the bridge.

Designed to permit flow through two concrete pipes.

Harvey Slow Rise – Copious Amounts of Water

Relief structure at Interstate near Houston. The frontage road was inundated, and extensive scour occurred at the bridge.

Scour hole caused by high flow over the frontage road. The embedment of the piling was significantly reduced

Emergency contract let to repair the scour hole. Note the water filled tubes in the background that allowed the region to be dewatered and the work to be performed.
Texas has numerous bridges with concrete riprap at embankments, even at water crossings. It can be highly problematic because it conceals large voids and doesn’t conform to changes in the slope. That is a practice we are trying to do away with.

A load test permitted us to reopen the bridge after initial analysis showed potentially insufficient capacity. If there is a slow rise and a rapid fall, the second event can result in more scour than the first. A second evaluation is frequently necessary if the initial evaluation occurs before the water has receded. In addition to scour, additional bank erosion can occur as the water recedes, largely due to weight of the saturated soil.

Before and after shots. The first photo was taken Saturday, 9/3/17, and the second on Sunday, 9/4/17. Damage doesn’t occur only when the water comes in; frequently scour and erosion can be significant as water levels drop.

It is critical to have ready access to current bridge files. – Channel Profiles – Inspection Reports (to determine whether damage was pre-existing). – Design/As-Built Plans Access to the Bridge Database, as well as someone who knows how to quickly query data. Also extremely important to have highly knowledgeable geotechnical engineers prepared to perform quick analyses given findings from the field. Try for what my boss calls a “courageous engineer,” someone willing to make competent decisions that are not overly conservative. Finding info has been a problem for us on off-system structures. Bridge plans have been hard to come by, even for relatively new bridges (less than 30 years old). Without knowing remaining embedment we are forced to close bridges if significant scour occurs.
Colorado River channel shifted 40 feet in this location.

According to channel profile and original plans, the bridge needed to be closed.

After noting differences between site conditions and plans, we found additional documentation on significant Field Changes that had not been incorporated into the As-Built Plans.

Turns out they had considered this exact scenario (channel migration) and made a change to include additional deep foundation elements after construction of the bridge commenced.

Hydrographs are an extremely powerful and useful tool. TxDOT is currently working with the National Weather Service and USGS to vastly expand the number of gages installed on bridges over waterways that are susceptible to flooding.

Debris is a major problem, regardless of whether there is a fast or slow rise in the water.

Particularly during Harvey, we observed bridges where the hydraulic openings were so clogged with debris that substantial channel migration occurred.

Fast moving debris can cause damage to bridge substructure elements.
Debris – Damage to Substructure

Clogged debris can exert enormous lateral loads on columns and piers. Older bridges with shorter spans catch a large amount of debris because of the increased number of substructure elements in the waterways.

Erosion at Bridge Ends

- In addition to scour issues caused by channel migration, debris also pushes water flow to bridge ends and frequently causes severe erosion at embankments, approach slabs, and roadways.
- Water flowing out of the main channels can lead to scour under approach spans and bents, which may not have been designed with deep foundations.
Erosion at Bridge Ends

But the Bridge Survived!

Channel Migration Due to Debris Build-up

Six bridges with varying span lengths and bent locations created a major debris catch.

The Good News

- Our bridges stood up extremely well to the flood events, particularly Harvey.
- There was a perception that there had to have been more damage than we were reporting - it actually became difficult for us to convince everyone that we were in good shape.
- Current design and construction practices, and the National Bridge Inspection Program, are doing their job.
- It’s important to help control the message. We had multiple reports of catastrophic bridge collapses being reported by various agencies and news outlets that were not even remotely accurate. Personal social media accounts are not legitimate news sources!
- Also important to help minimize the hysteria. Responding during these events is extremely stressful and tiring. It is critical to maintain a level-headed approach, stay focused on the systematic tasks at hand, and work to alleviate the fears of others.
The Bad News

- The instances of significant scour are rare and isolated. This was particularly the case with Harvey (I know, that sounds like good news).
- We found that there is little rhyme or reason to when or where significant scour events will occur. It wasn’t along the same waterways, in the same geographic regions, or any other common denominator.
- At the end of the day, we have to accept that water does funny things. It’s unpredictable, and so is scour and erosion.

Our Conclusion?

- We needed to put eyes on every single on-system water crossing in the Houston and Beaumont regions (over 4,000 bridges).
- Over the course of approximately four weeks we accomplished that using in-house and consultant forces.
- Significant damage occurred at only a handful of bridges, but due to the random nature of the scour and erosion the widespread evaluation was necessary.
- Almost every bridge that experienced significant scour or erosion was not on our list of “at risk” structures.

QUESTIONS?

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