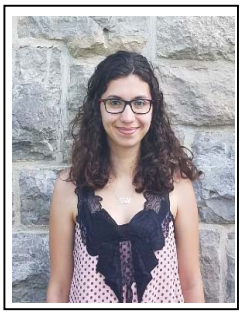
Soil Mechanics of Coastal Erosion in Response to Hydrodynamics and Morphodynamics



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Project Background

Climate change and sea level rise are two major societal challenges (NAS 2010; Hinkel et al. 2014). Previous studies showed that there is a strong association between long-term sandy beach erosion and sea level rise. In addition to sea level rise, the frequency of severe storm events is expected to increase, which will lead to more extreme effects associated with such events. Significant sediment transport, erosion, and redeposition events are almost always linked with such storm events. Despite this severe threat, prediction models have difficulty in correctly simulating the impact of severe storm events at many locations (Coco et al. 2014). Thus, the need to better understand the correlation between sediment erodibility and geotechnical sediment properties arises to accurately predict sediment coastal erosion.

Project Objectives

Sediment erosion in coastal environments depends on (i) hydrodynamics, representing the driving forces, (ii) geomorphology, and (iii) sediment properties. The project aims to better predict coastal erosion by understanding how geotechnical properties are affected by geomorphodynamics and hydrology. Therefore, the two main research objectives of this study are:

- Measuring and assessing sediment strength and pore pressure response of nearshore and coastal sediments under hydrodynamic forcing and ongoing morphodynamics.

- Modifying the Shields parameter equation to better predict the initiation of sediment transport. The critical shear stress required to initiate sediment transport and erodibility depends on shear strength $\boldsymbol{s_u}$, and pore pressure behavior $\boldsymbol{u_{ex}}$. It is hypothesized that the Shields parameter $\boldsymbol{\theta_{cr}}$, and the equation for erosion rate E can be modified by expressing them as functions of $\boldsymbol{s_u}$ and $\boldsymbol{u_{ex}}$, with the resulting relationships being able to provide an improved prediction of erodibility.

Research Plan and Progress

A list of research tasks and key findings is provided below:

1. A literature review was conducted, gathering previous work done in predicting coastal erosion and estimating sediment strength from penetrometer measurements. (In progress)

2. Several site investigations are needed for this project to provide an adequate data set. (In progress)
   The first site investigation was conducted in three rivers in Texas after Hurricane Harvey, a category 4 hurricane. Hurricane Harvey caused storm surges and flooding in Texas and Louisiana. River bank failures, sediment deposits on roads, and scour holes near bridge pillars were documented after the hurricane. Three locations in the Guadalupe, Colorado, and the Brazos Rivers were investigated for this project. (Completed)
   For this data set, the subtasks can be summarized as follows:
   - Free fall penetrometer (Bluedrop) data was processed to predict the sediment strength and pore pressure responses in sediments. Fig. 1 presents the quasi-static bearing capacity (*qsbc)* of soil along a cross-shore transect in the Brazos River. (Completed)
   - Laboratory testing was conducted to determine the sediment grain size distribution and strength. (Completed)
   - Analyze the acoustic Doppler current profiler data to estimate hydrodynamic forces. (In progress)
   - Analyze the variations in sediment properties observed between the three rivers and within the three rivers, and correlate it to flow properties. (In progress)
   - Correlate major erosion events with hydrodynamics and bed shear stress. (Not yet started)

   A similar strategy of data collection and analysis will then be applied to other sites impacted by storm events. The next experiment is planned in Duck, North Carolina, in Fall 2019.
3. Conducting more laboratory tests to determine soil strength and experiments to determine critical shear stress of the soil. (In progress)
4. Deriving general correlations for different sites and soil types. (Not yet started)
5. Modifying Shields parameter equation to better predict the initiation of sediment transport. (Not yet started)

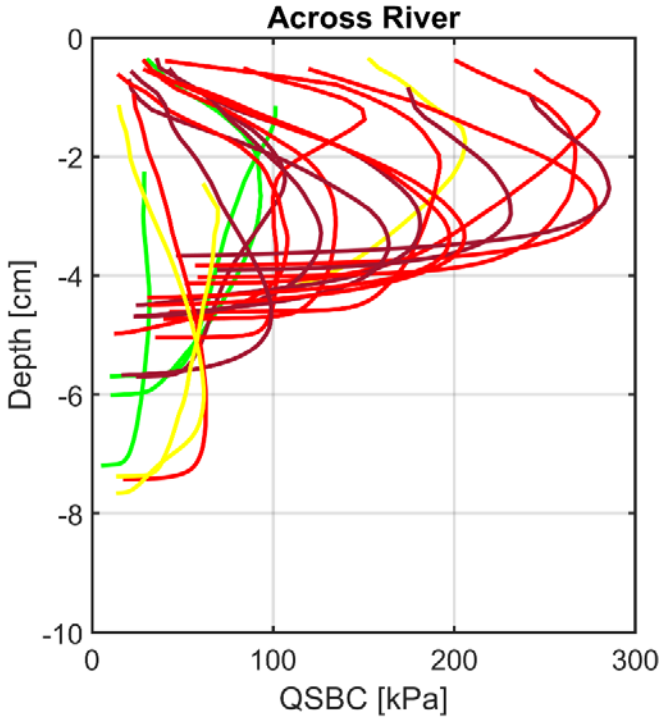

Figure 1. Estimates of quasi-static bearing capacity vs. sediment depth across the Brazos River.