



# Free Fall Penetrometer Data Analysis Application

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## INTRODUCTION

Free Fall Penetrometers (FFP) are small devices deployed from boats to measure soil strength and pore pressure. These measurements are further analyzed to characterize soil sediment, providing important data for offshore site development. The existing data analysis methods utilized by ocean researchers lack a graphical user interface, are spread across multiple tools and programming languages, and do not provide any validation of user input. Last year's development team created a desktop application that combined all existing data analysis functionality with a graphical interface.

Our goal was to refactor this application to incorporate relative density calculations, expansion of soil classification, friction angle calculation, and pore pressure properties. These features were implemented while maintaining the application's efficiency, ease of interaction, and accuracy.



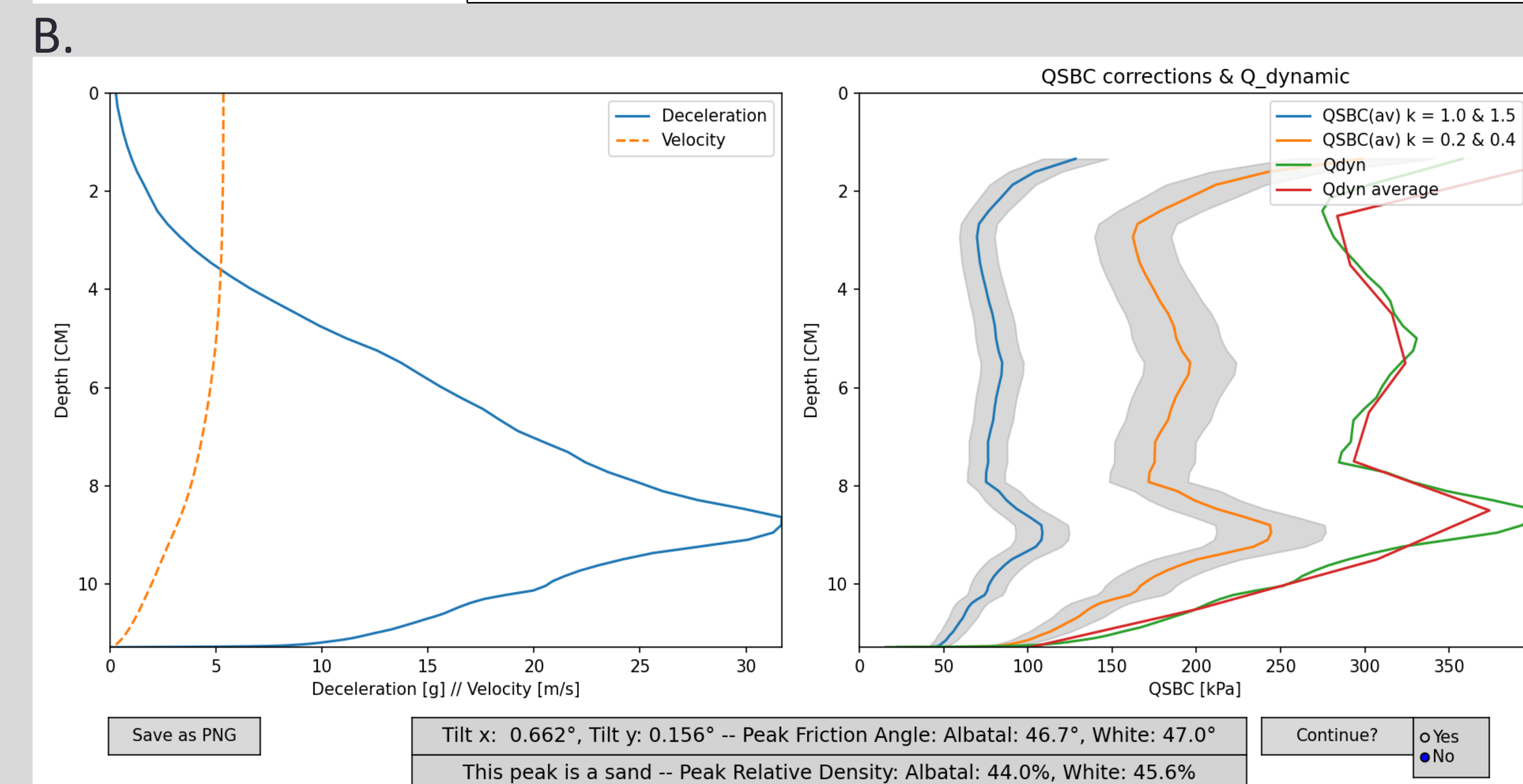
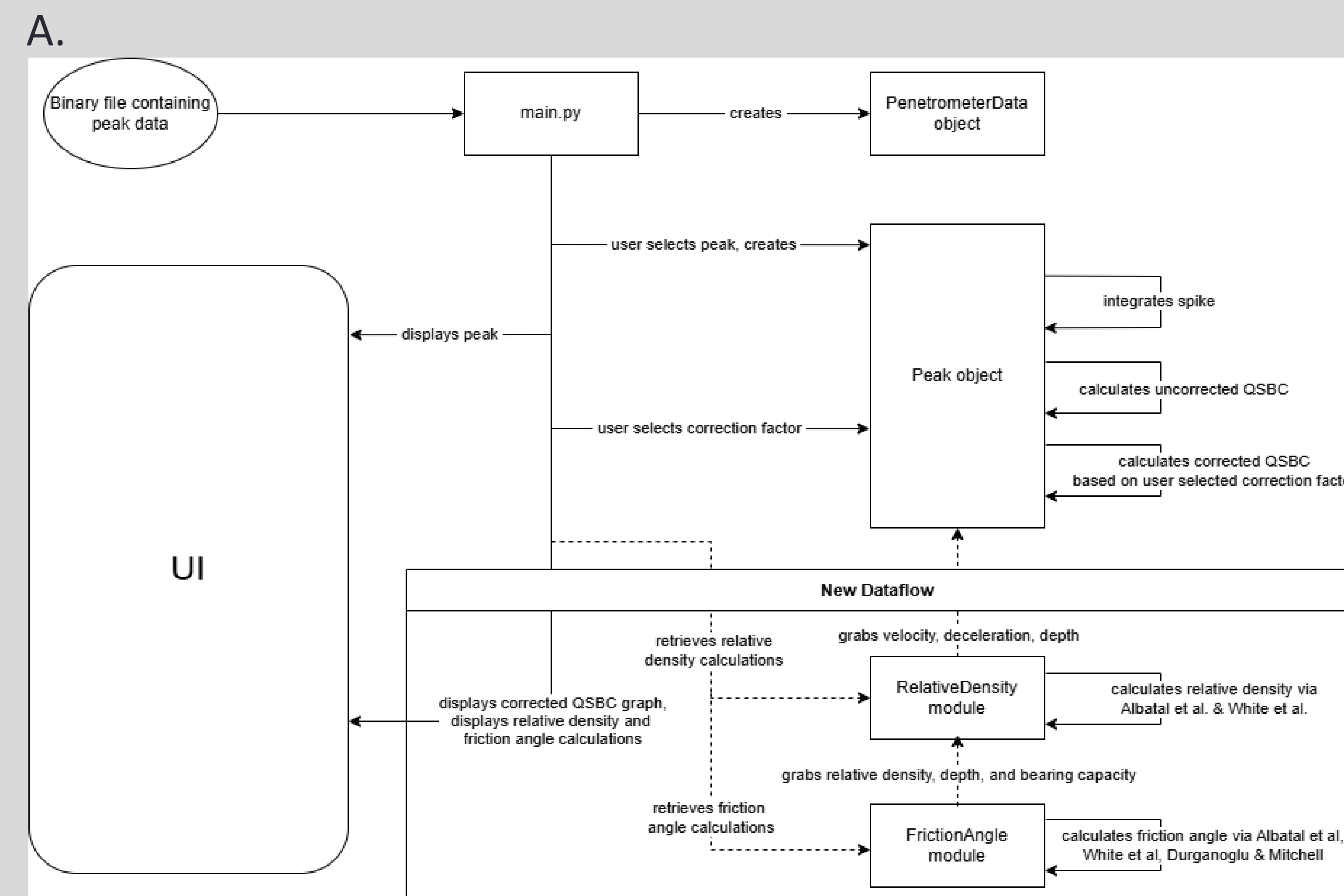
## REQUIREMENTS

- Functional:
  - All graphical data is saved to appropriately named .csv files
  - Analyze data using specified correction types
  - Outputs bearing capacity graph based on user-inputted values
  - Correctly classifies soil type based on penetration depth
  - Calculates relative density and friction angle for certain soil types
  - Analyze data to visualize pore pressure
- Non-Functional:
  - Intuitive user experience with no terminal usage
  - Only valid inputs are processed
  - User input to data output is under three seconds

## IMPLEMENTATION

Our project uses Python 3.10+ with *NumPy*, *SciPy*, *Shapely*, *matplotlib*, *pandas*, and *Tkinter* for computation, visualization, and GUI development. These tools were best for unifying all existing functionality in a modular way that is easy to understand and be improved on, and using Python was the best choice to allow the project to be packaged as a complete application.

## DESIGN



- A. Data flow diagram illustrating how the system calculates relative density and friction angle, and presents the results with QSBC graph.
- B. Image of User Interface after calculating Quasi-Static Bearing Capacity, Friction Angle, and Relative Density

## TESTING

We successfully generated and validated graphical outputs, ensuring consistency with existing MATLAB, Excel, and Python results by directly comparing graphs and numeric data. We have also created new unit tests to help future contributors change the code and ensure they do not introduce errors to the existing functionality. Soil relative density and friction angle calculations were tested against existing processed data provided by the project sponsor.

## EVALUATION & CONCLUSION

New data calculation and representation such as relative density and friction angle help provide the user a more centralized experience, preventing the need to perform these calculations outside of the application. Improvements to the display of quasi-static bearing capacity and other FFP data have increased clarity and improved the flow of the application. New values for users to input have boosted the flexibility and usability of the application tremendously, allowing users to experiment with plots. Additionally, input validation and plotting limits data entry errors and prevents them from corrupting a data analysis session. These factors allow ocean engineers to focus on the results of the data rather than the analytical process itself.

## FUTURE WORK

- Implement additional penetrometer data analysis modules based on geotechnical strength properties
- Add/improve upon soil characterization models
  - More complex and accurate models that consider variance of data; allowing user-input data at runtime
  - Models to predict more types of soil
- Extend analysis of pore pressure data

## ACKNOWLEDGMENTS

Project Sponsor: Julie Paprocki  
Faculty Advisor: Lisa Henry