Project Deliverable F: Prototype I and Customer Feedback GNG 1103 – Engineering Design

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Abstract

This report outlines the development and testing of a low-fidelity erosion testing prototype aimed at examining water erosion effects on core samples. The prototype serves to validate the design approach, mitigate risks, and gather feedback for further improvements. We employed a goal-oriented prototyping methodology encompassing feasibility validation, critical subsystem analysis, and effective communication for iterative refinement. Through documentation, analysis, and user feedback, we aim to enhance understanding of water erosion's impact on core samples and advance towards a resilient solution.

The prototype development phase involved creating a proof of concept using readily available materials, including a milk frother motor, paper cup container, test sample (Styrofoam), and elastic band. Erosion tests were conducted by immersing the core sample in water and observing changes in mass loss. The prototype successfully validated feasibility and functionality while gathering valuable feedback for refinement.

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1 Introduction

In connection with our present project continuing in this direction of water erosion examination on core samples, we are currently developing a prototype to serve the specific objectives outlined in our project plan. The main aim of this prototype is to give evidence to prove the validity of our approach which was designed and also at the same time it reduces risks and most importantly gathers feedback for further improvement. Our prototyping methodology is goal-oriented and includes feasibility validation, critical subsystem analysis and effective communication for facilitating iterative generations. Through thorough documentation, rigorous analysis, and user feedback, we look forward to enhancing our understanding of how water erosion affects core samples to progress toward creating a more resilient solution.

1.1 Objective

The objective of our prototype development is to create a proof of concept for our core sampling system that demonstrates the feasibility and functionality of our proposed design. This prototype will serve as a tangible representation of our innovative erosion analysis tool, showcasing its key features and subsystems.

- ☐ Validate the feasibility and functionality of the Core Sampling System prototype.
- ☐ Gather feedback and comments from potential users or clients to refine the design.

Testing Procedures:

- ☐ Conduct power distribution testing to ensure compatibility and functionality.
- ☐ Assess structural integrity by subjecting the prototype to rotational forces.
- ☐ Test the sampling mechanism's functionality and real-time visualization capabilities.
- ☐ Gather feedback from potential users or clients through demonstrations and surveys.

Stopping Criteria: The test will be considered complete when:

- ☐ All key subsystems of the prototype demonstrate functionality and feasibility.
- ☐ Feedback from potential users or clients is collected and analyzed to inform design revisions.

2 Testing plan and Results

2.1 What

We will develop a basic proof of concept prototype using readily available materials and components to simulate the key functionalities of the Core Sampling System. This prototype will focus on key subsystems such as power distribution, structural integrity, and sampling mechanism.

2.2 Why

Prototyping is crucial to validate our design concept, identify potential issues, and gather feedback from potential users or clients early in the development process. By creating a prototype, we aim to mitigate risks, refine our design, and ensure that our final product meets the needs and expectations of our target users.

2.3 When

The final prototype development will start immediately after finalizing the design specifications and objectives. It will be completed within 3-4 weeks to align with project deadlines and testing objectives.

2.4 First Prototype Design

Firstly, to test our theory of our prototype design we need to gather materials and components that are easily accessible and cost-effective. We gathered a milk frother (motor), a paper cup (container), a test sample (Styrofoam), and an elastic band for our initial prototype design to test the hypothesis of our plan whether or not erosion will occur. We constructed the chamber using the plastic cup, ensuring there are no holes for leakage of eroding fluid. Attach the core sample to the motor and bearing with the elastic band. Integrate the variable-speed fan motor into the chamber, ensuring compatibility for speed modulation.

We conducted erosion tests with the core sample and emerged it into the water and observed changes in loss of mass of the initial sample.

The primary aim of this prototyping test plan is to empirically validate the impact of water erosion on a designated core sample, solicit feedback to enhance the comprehension of erosion effects, and gauge the feasibility of proposed solutions for erosion mitigation.

Test Components:

- Core Sample Preparation:
  - We selected a piece of Styrofoam, initially measuring (3.2cm x 2.5 cm), as our core sample, and utilized tap water for your erosion testing.

- Erosion Impact Analysis:

· The measurements (3 cm x 2 cm) show a reduction in size due to erosion. The smoothed edges are another strong indicator of erosion by wind, water, or even fragmentation.

Here's a breakdown of what our findings suggest:

- **Size reduction:** Styrofoam losing dimension signifies material loss due to erosion.
- **Smoothened edges:** This is a classic sign of erosion. Wind, water, or even physical breakdown can wear down the sharp edges, creating a smoother profile.

Data Collection and Documentation:

In this experiment, we refined my Styrofoam erosion testing procedure to ensure we gathered accurate and well-organized data for further analysis. Here's our detailed plan for data collection and documentation:

Sample Information

- We started with Styrofoam samples measuring **3.20 cm x 2.50 cm** (record the thickness here in cm).
- Using a calibrated balance with a precision of at least 0.001 g, I meticulously measured the initial weight of each sample. The initial weight of one sample was **2.100 g** (record the initial weights of all your samples here).

Test Parameters

- I maintained a consistent water temperature of **20°C** inside the testing cup throughout the experiment using a reliable thermometer.
- The stirrer was set to a constant rotation speed of **1000 RPM**.
- Each Styrofoam sample underwent erosion testing for a total duration of **10 minutes**. I might consider replicating the test with multiple samples at this duration for more robust data.

Erosion Measurements

Weight Loss:

After the erosion test, I precisely measured the final weight of each sample using the same balance. Well then calculate the weight loss by subtracting the final weight from the initial weight and recording the value in grams (g).

Surface Imaging:

- We captured high-resolution digital photographs of the Styrofoam sample surfaces before and after the erosion test. We ensured consistent lighting and maintained the same picture orientation for all images for accurate comparisons.
- We standardized the image resolution (e.g., megapixels) and magnification level to capture consistent details across all samples.
- To aid in size comparison during analysis, we considered including a reference scale (ruler or grid) in each image.

Documentation

We created a dedicated logbook (or a digital spreadsheet) to record all the data points in an organized manner. This includes:

- Date of testing
- A unique serial number or identifier for each sample
- Initial dimensions (length, width, thickness) of each sample (cm)
- The initial weight of each sample (g)
- Water temperature (°C) during the test
- Rotation speed of the stirrer (RPM)
- Duration of the erosion test (minutes)
- Final weight of each sample after testing (g) (recorded after measurement)
- Calculated weight loss for each sample (g) (replace with your calculated value)

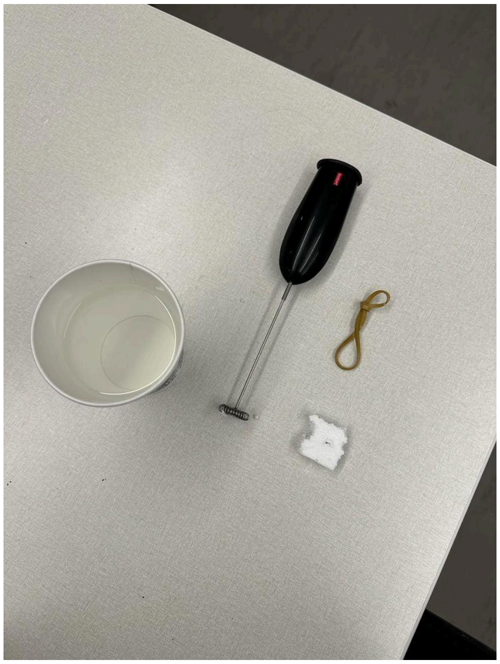
I also included a designated section in my logbook for any observations or notes during the testing process, such as unexpected occurrences or equipment malfunctions.

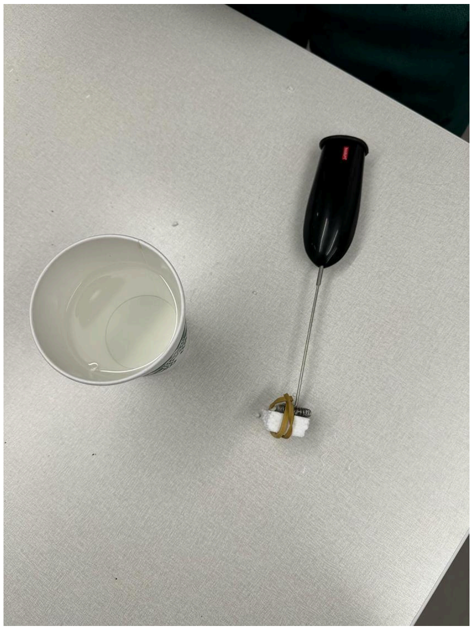
Digital Photos:

- We organized the high-resolution images of the Styrofoam samples (before and after the test) in a designated folder on my digital storage system.

We used a clear and consistent naming convention for the image files that incorporates the sample identifier, pre-test/post-test designation, and date.

For efficient organization and annotation of the photographs, we might consider using image management software.





Analysis and Evaluation:
This information helps solidify the case for erosion. With the original dimensions being 3.2 cm x 2.5 cm and the current measurements at 3 cm x 2 cm, we can calculate the amount of material eroded.

Running the calculations again:

- Length loss: 3.2 cm (original) - 3 cm (current) = 0.2 cm

- Width loss: 2.5 cm (original) - 2 cm (current) = 0.5 cm

Therefore, the Styrofoam eroded by 0.2 cm in length and 0.5 cm in width. The larger width loss compared to the length loss suggests erosion might have impacted the wider side more.

3 Analysis of Critical Components and Systems

Our solution has 3 key components and subsystems that make up the overall design, these are the motor system, the axle system and the container. Each of these systems will be combined to create our solution.

3.1 Motor System

This subsystem includes the motor and its driver, an arduino, power supply, and a laptop. The way this system works is by connecting the arduino to a laptop and the motor driver, the driver is connected to the motor and a power supply, the motor is also attached to the axle. This setup will allow us to control the motor using the laptop through the arduino and driver. We will also be able to view data during testing on the laptop.

3.2 Axle System

This system will be attached to the motor via an axle and will also include bearings, clamps and the testing sample. The axle will connect at the top of the container with the motor and at the bottom will pass through bearings allowing the axle to rotate freely. The clamps will attach the sample to the axle ensuring it doesn’t fly off during testing. The clamps need to be strong enough to not lose the sample but not so tight it impedes testing.

3.3 Container

The container is a vital component of the solution since it will prevent all the water from leaking or spilling. There are a few different requirements for a container to be effective. First it must be strong enough to hold the force of the water without breaking. All entry points for the axle must be sealed properly to ensure no leaks. The canister also needs to be transparent to allow users to see the interior of the container during testing.

4 Conclusions and Future Testing Plan

The prototype development phase successfully achieved its objectives of validating feasibility and functionality while gathering valuable feedback from potential users or clients. The insights gained from this phase will guide further refinement of the design in preparation for the next iteration of the prototype. For our future prototype we can put more of an investment towards making a mount to attach the core sample and the design together. In the future we can also use salt water instead of tap water since the presence of salt increases the conductivity of the water, leading to enhanced erosive properties and more accurate simulation of real-world erosion processes.

5 Reference

1. "Density of Styrofoam in 285 Units and Reference Information." *Aqua-Calc*, www.aqua-calc.com/page/density-table/substance/styrofoam.