Project Deliverable D: Conceptual Design GNG 1103 – Engineering Design

Faculty of Engineering – University of Ottawa

Abdul Ahad

Charlie Gordon

Ahmed Mohsin

Abstract

This study presents an advanced Erosion Simulation and Modeling System utilizing sophisticated equipment for accurate replication of diverse erosion processes. The system integrates data to generate realistic scenarios, simulating water erosion .

This model facilitates nuanced visualization of erosion evolution, aiding stakeholders in assessing interventions and conservation strategies. With a user-friendly interface, it caters to a diverse audience of researchers, policymakers, and educators, contributing to a comprehensive understanding of erosion dynamics. The Erosion Simulation and Modeling System stands as a pivotal academic resource, advancing research and promoting sustainable land management practices globally.

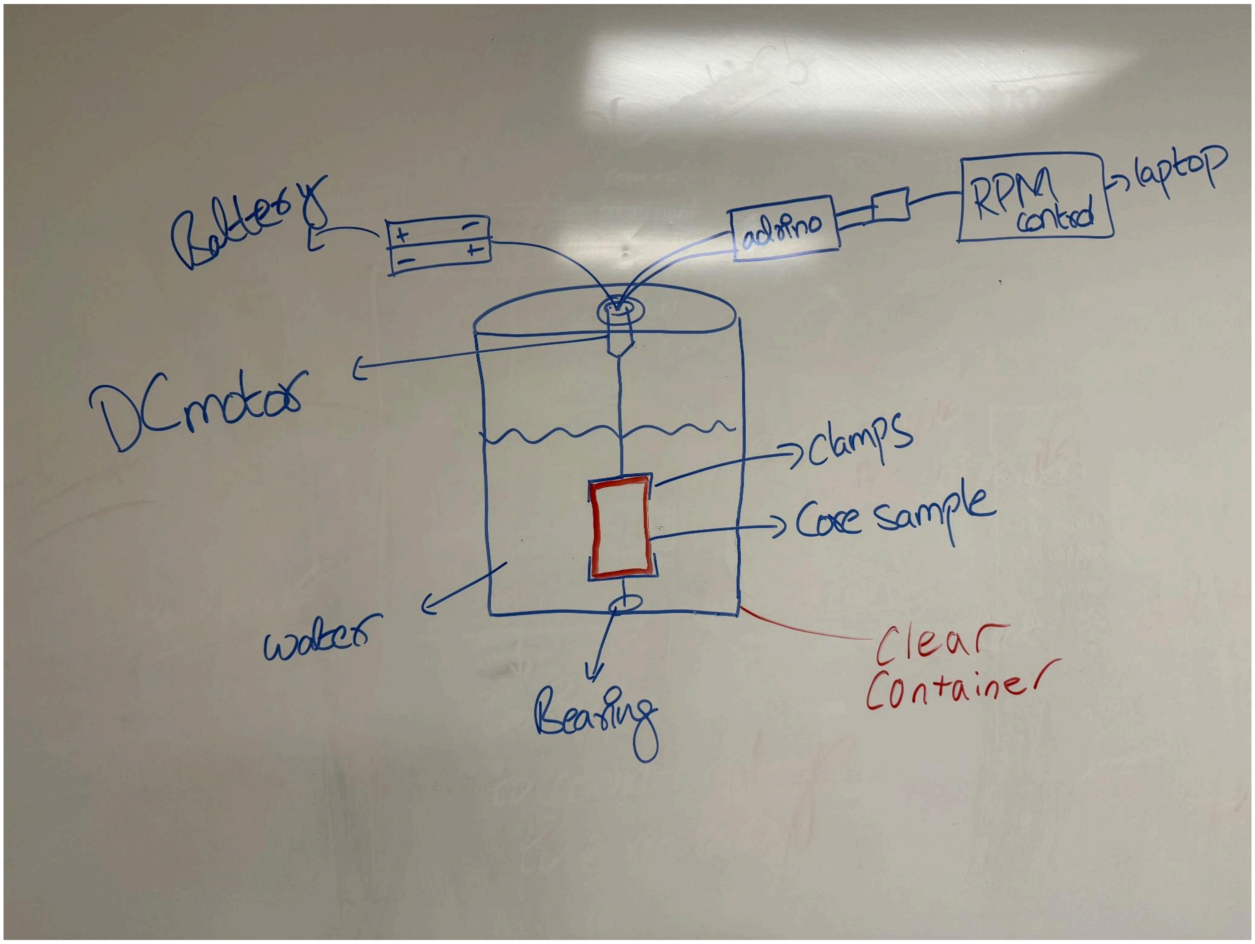
Table of Contents

1. Introduction

Within the field of environmental science and land management, the Erosion Simulation and Modeling System stands as a significant advancement in addressing the challenges posed by erosion. This chapter delves into the intricacies of this innovative tool, designed to simulate and model erosion processes with unprecedented precision.This system enables the generation of realistic scenarios across various erosion types.This exploration aims to unravel the Erosion Simulation and Modeling System's potential to enhance our understanding of erosion phenomena.

2. **Erosion Simulation and Modeling system 1:**

Sketch:



Description: This study presents the design and implementation of a core sample rotation system, utilizing a direct current (DC) motor integrated with an Arduino microcontroller. The core sample, secured by clamps, undergoes controlled rotation, facilitated by the Arduino-based system. This arrangement enables precise manipulation of the motor's revolutions per minute (rpm), providing researchers with a reliable mechanism to examine and analyze geological core samples. The connection between the DC motor and Arduino, as well as the subsequent link to a laptop, establishes a seamless control interface for efficient experimentation and data acquisition.

System Requirements

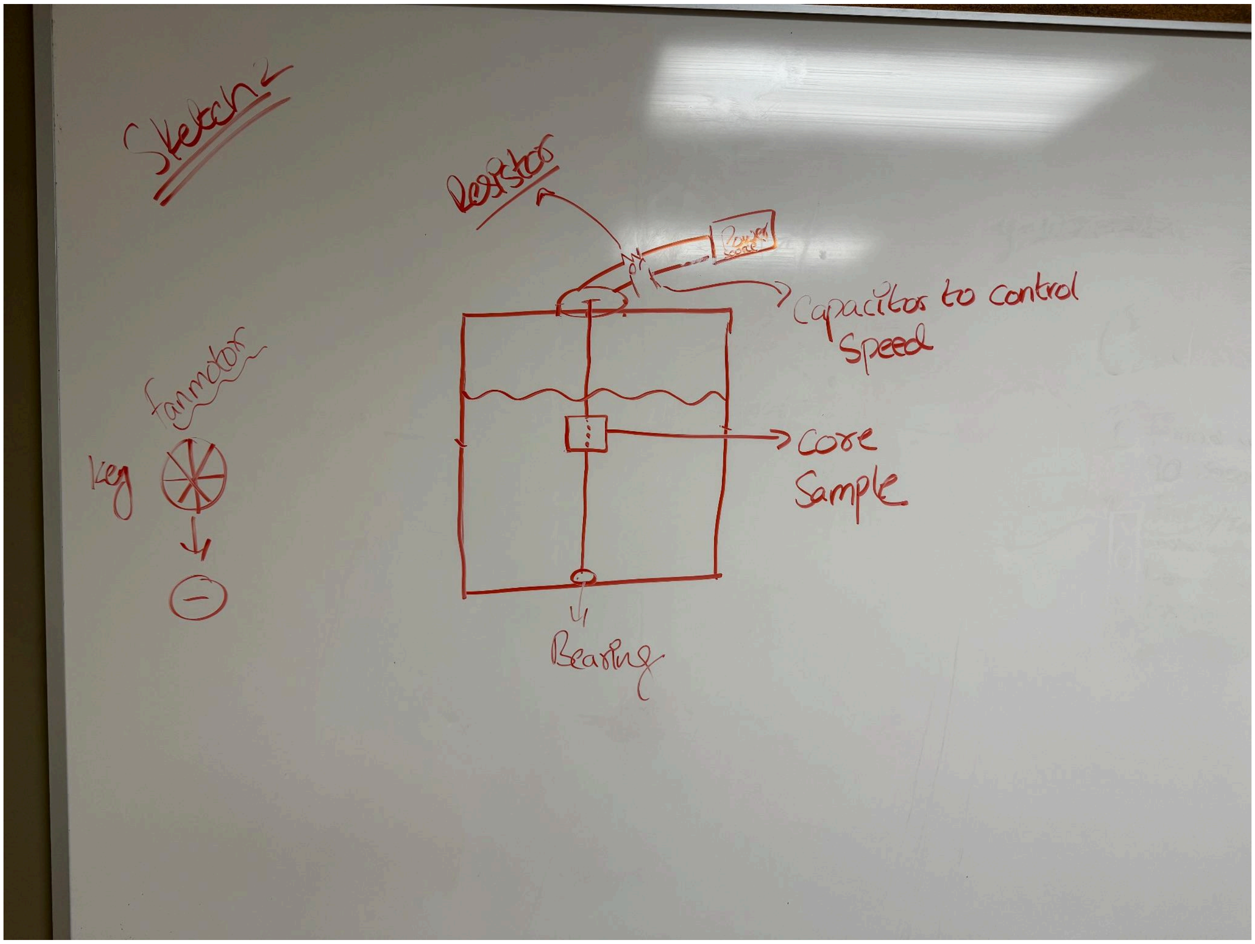
Core Sample Clamping: The core specimen is held securely with clamps to ensure stability during rotation. These design considerations are important to prevent migration or misalignment of the model.

DC Motor Selection: . The selection of a DC motor depends on its suitability for precise rotational speed control. Motor selection depends on factors such as torque, rpm range and power consumption.

Arduino Interface: The DC motor is connected to an Arduino microcontroller, allowing real-time control of the rotation speed. The Arduino facilitates a seamless connection between the motor and an external device, such as a laptop

3. Erosion Simulation and Modeling system 2:

Sketch:



Description: The system operates by inducing rotational motion in a cylindrical apparatus through the utilization of a fan motor, the speed of which can be modulated via a variable resistor or capacitor. A metallic rod serves as the linkage between the motor and the sample, affixed securely on both ends or penetrating through the specimen. At the base of the container, the rod is affixed to a bearing mechanism. The sample, ensconced within a transparent rectangular container, is immersed in an eroding fluid. Throughout the testing procedure, the sample undergoes visual scrutiny, and its pre- and post-testing mass is ascertained through meticulous drying and weighing procedures.

System requirements:

4. **Fan Motor:**

   Type: Variable-speed fan motor

   Compatibility: Capable of interfacing with a variable resistor or capacitor for speed modulation

   Power: Sufficient power capacity to induce rotational motion in the cylindrical apparatus

   Reliability: Stable performance and durable construction

5. **Metal Rod:**

   Material: Corrosion-resistant metal (e.g., stainless steel)

   Dimensions: Appropriate length to connect the motor to the sample

   Rigidity: Sufficient stiffness to transmit rotational motion effectively

6. **Bearing Mechanism:**

   Type: Robust and low-friction bearing for smooth rotation

   Stability: Capable of securely supporting the rod and withstanding rotational forces

   Durability: Long-lasting and resistant to wear under testing conditions

7. **Cylindrical Apparatus:**

   Material: Chemically inert and corrosion-resistant material

   Dimensions: Suitable size to accommodate the sample and allow for rotational movement

   Construction: Well-sealed to prevent leakage of eroding fluid

8. **Rectangular Container:**

   Material: Transparent and chemically inert material

   Dimensions: Sufficient size to house the sample and eroding fluid

   Clarity: Clear visibility for visual monitoring of the sample

9. **Variable Resistor or Capacitor:**

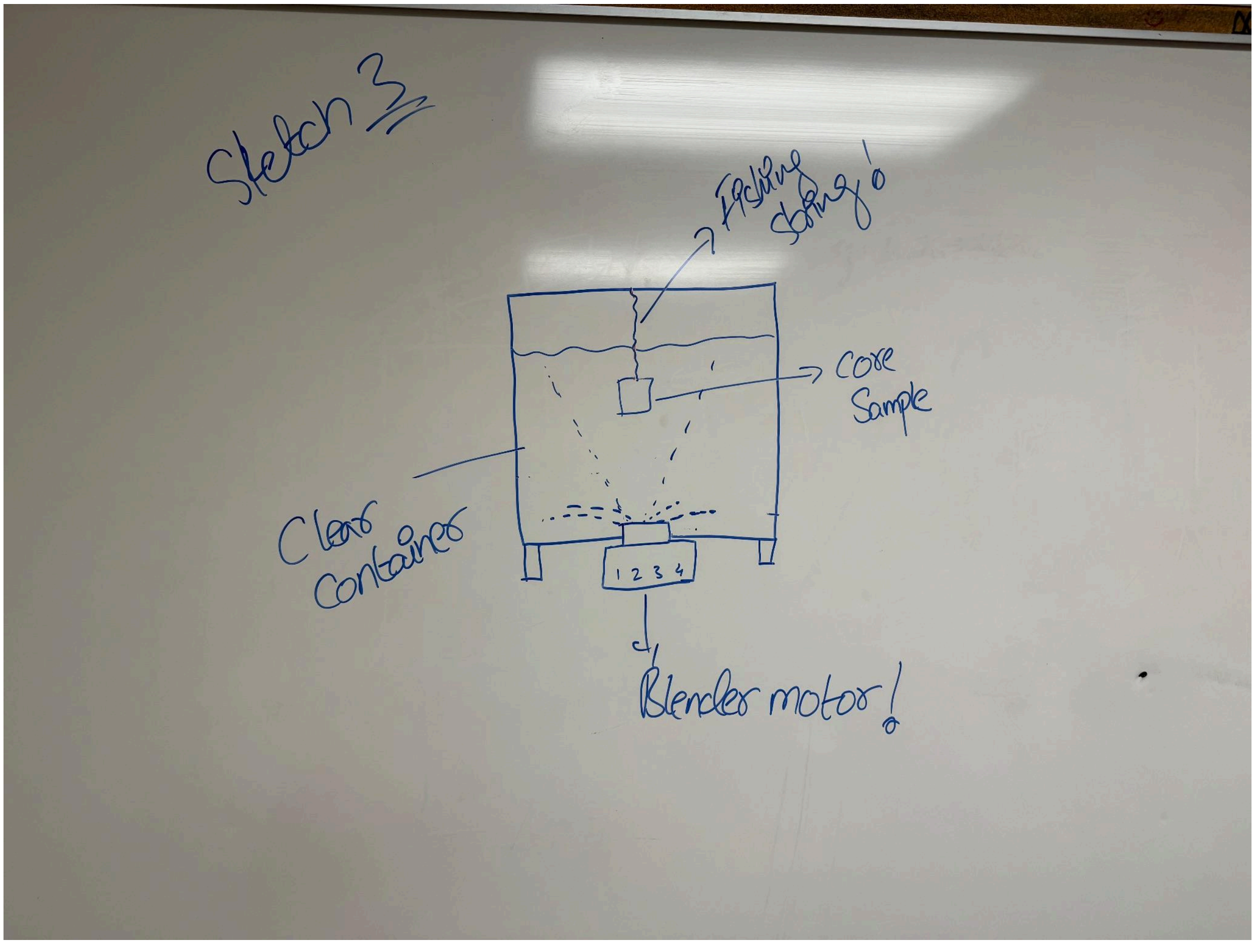
   Type: Compatible with the fan motor for speed control

   Precision: Fine-tuned adjustment capabilities for controlling rotational speed

   Stability: Consistent performance for reliable experimentation

Erosion Simulation and Modeling system 3:

Sketch:



Description: This study presents the development of an innovative experimental apparatus designed to investigate accelerated erosion processes. The model employs a transparent container wherein the sample is suspended in water using fishing lines. A blender motor, analogous to conventional kitchen blenders, is positioned at the base of the container and is intricately connected to an interlocking gear system. The gear system propels fan blades into the water, generating rapid currents with the objective of accelerating the erosion of the suspended sample.

System Requirements:

Container:

- Material: Transparent and durable material for clear visibility.
- Dimensions: Sufficient size to accommodate the sample and allow for observation.
- Sealing: Watertight seals to prevent leakage during experiments.

Suspension System:

- Fishing Line: High-strength and corrosion-resistant material for suspending the sample.
- Attachment Points: Securely attached to the container to maintain stability.

Motor:

- Type: Blender motor or equivalent.
- Power: Adequate power to drive the gear system and fan blades.
- Speed Control: Variable speed control for adjusting erosion rates.
- Waterproofing: Necessary protection to ensure safe operation in a water environment.

Gear System:

- Interlocking Gears: Precision-engineered gears for efficient power transmission.
- Gear Material: Corrosion-resistant material to withstand exposure to water.
- Lubrication: Provision for lubrication to minimize friction and ensure smooth operation.

Fan Blades:

- Material: Resilient and non-corrosive material suitable for immersion in water.
- Blade Design: Optimized design for generating fast-moving currents.

Benchmarking:

- Masses of core samples ranging from 0 to 40g

- Up to 1750 rpm
- Core size: 75mm in diameter and 89mm in height
- Record in stages of 10 to 30 min
- Use torque to calculate shear stress

Advantages:

- A small amount of water is needed
- High shear stress can be generated

The shear stress can be estimated by using the induced torque on the side surface.

4. Conclusions

In conclusion, System One emerges as the more precise option, affording a heightened degree of control over the system in comparison to the other two alternatives. Nevertheless, it is imperative to acknowledge the inherent limitation of System One in lacking rotational power. Contrarily, Systems Two and Three exhibit superior revolutions per minute (rpm), facilitating a rapid demonstration of erosion effects. However, their efficacy is compromised by a notable deficit in control, as manipulative interventions are constrained within certain bounds. The trade-off between precision and rotational power necessitates a judicious selection based on the specific requirements and objectives of the application at hand.

5. References

1. Lim, S. S., & Khalili, N. (2009). An improved rotating cylinder test design for laboratory measurement of erosion in clayey soils. *Geotechnical Testing Journal*, *32*(3), 101448. https://doi.org/10.1520/gtj101448
2. Movahedi, H., & Jamshidi, S. (2022). New insight into hydrodynamic and cake erosion mechanism during rotating-disk dynamic microfiltration of concentrated bentonite suspensions at different salinity conditions. *Separation and Purification Technology*, *300*, 121844. https://doi.org/10.1016/j.seppur.2022.121844

3. Deng, T., Bingley, & Bradley, M. S. (2004). The influence of particle rotation on the solid particle erosion rate of metals. *Wear*, *256*(11–12), 1037–1049. https://doi.org/10.1016/s0043-1648(03)00536-2