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In this issue

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Water Resources Engineering Department
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Editor in Chief: Sarkawt H. Muhammad
College of Engineering Salahaddin University-Erbil

Assoc. Prof. Dr. Ahmed Salih
Sulaimani Univ. and AUIS

Unlocking the Potential of Chemical Oxides for Enhanced Soil Stability

Soil stability is crucial for the safety and longevity of construction projects. Unconfined compressive strength (UCS) is a vital metric for assessing soil strength. It measures a soil's resistance to failure under pressure, directly influencing foundation reliability. This research highlights the transformative role of chemical oxides in improving soil geotechnical properties, specifically UCS, Liquid Limit (LL), and Plasticity Index (PI).

This study highlights the critical role of Unconfined Compressive Strength (UCS) in ensuring soil stability for safe construction. It examines how chemical oxides such as CaO, SiO_2, Al_2O_3, MgO, and Fe_2O_3 influence UCS and key soil parameters like Liquid Limit (LL) and Plasticity Index (PI). Using a Full Quadratic model, researchers analyzed these oxides' effects individually and combined with fly ash, a supplementary material.

The findings show that SiO_2 and Al_2O_3 significantly reduce LL and PI, enhancing soil stability. Sensitivity analyses revealed Al_2O_3 as the most influential for LL and SiO_2 for PI. Fly ash further boosts UCS by optimizing soil composition to minimize porosity. These insights present innovative soil stabilization strategies, promoting durable and sustainable construction practices, which are essential as urban growth and climate challenges increase demands on geotechnical engineering.

1.The Role of Chemical Oxides

Chemical oxides are key agents in altering soil properties:

- Calcium Oxide (CaO): Often used in lime treatments, CaO improves soil cohesion and reduces plasticity, making it less susceptible to deformation under stress.
- Silicon Dioxide (SiO_2): Known for enhancing soil's structural integrity, SiO_2 reduces PI, thereby limiting soil expansion and shrinkage.
- Aluminum Oxide (Al_2O_3): Al_2O_3 aids in strengthening bonds between soil particles, influencing LL and PI significantly.
- Magnesium Oxide (MgO): Contributes to soil stability by improving hydration processes and reducing LL.
- Ferric Oxide (Fe_2O_3): Plays a secondary role but contributes to overall stability when combined with other oxides.

2. Experimental Insights and Model Applications

Using a Full Quadratic (FQ) model, the study quantifies how these oxides interact with fine soil content and additives like fly ash, widely known for its cementitious properties. Fly ash contains high levels of SiO_2 and Al_2O_3, amplifying its soil stabilization effects. The research highlights:

- SiO_2 and Al_2O_3 as the most effective oxides in improving soil strength by reducing LL and PI.
- Fly ash as an additive that minimizes porosity and enhances UCS, especially at optimal content levels.

3. Sensitivity Analysis

A sensitivity analysis uncovered nuanced interactions between oxides and soil properties:

- Al_2O_3 emerged as the most significant factor affecting LL.
- SiO_2 had the greatest impact on PI.
- Combining oxides in tailored proportions allowed for optimal UCS improvements.

4. Practical Implications

- These findings have substantial implications for geotechnical engineering:
- Road and Embankment Construction: Stabilized soils with enhanced UCS can support higher loads, reduce settlement, and withstand environmental stresses.
- Sustainable Practices: Using fly ash, a byproduct of coal combustion, aligns with circular economy principles, reducing waste and promoting sustainability.
- Cost-Efficiency: Chemical treatments that improve soil properties reduce the need for extensive foundation works, cutting project costs and timelines.

Dr. Mohammed G. Mohammed

Lecturer

Theory and Practice of the Hydrodynamic Redesign of Artificial Hellbender Habitat

Collaboration between a biologist and several engineers resulted in the redesign of a previously employed rectangular Hellbender nest box to meet biological requirements and improve field performance. Analysing the functioning of the nest box from the perspective of hydrodynamics identified at least partial reasons for observed instability and sedimentation around the downstream access tunnel. The analysis further suggested how the redesign should be undertaken: producing modifications to the upstream face in order to reduce drag caused by flowing water and to the downstream face to complete the redirection of streamlines around the nest box to limit sedimentation. The more than four-fold increase in the predicted velocity of flow required to destabilize the streamlined nest box as compared to the rectangular nest box (as produced by demonstration calculations), suggests that it is a tool with a greater likelihood of success in augmenting Hellbender populations in North Carolina stream sites. At this time, researchers in North Carolina are in the process of building, installing and testing the efficacy of the redesigned nest box in the field. Results from the field testing will be incorporated into future refinement of the design.

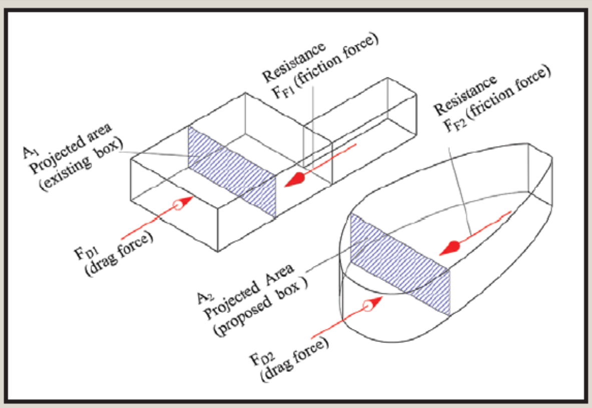


FIG. 5. Projected area and orientation of the drag and friction forces for the rectangular and streamlined shapes.

FIG. 6. Photographs of the streamlined nest box prototype.

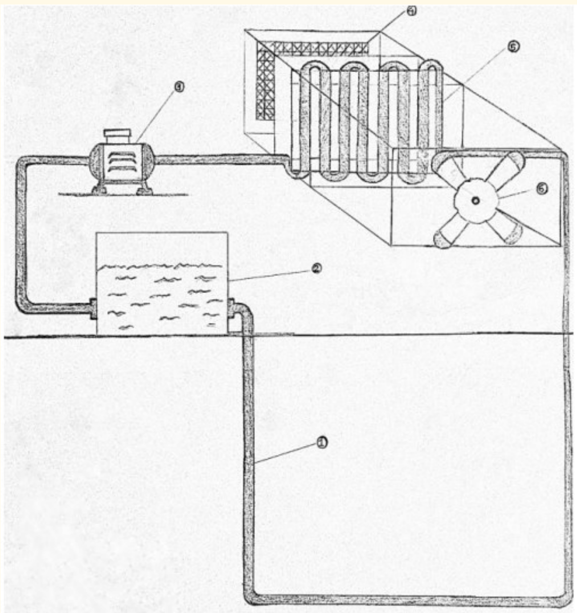
Rashad Mohammed Hassan

Assistant Lecturer

Geothermal Heating and Cooling System Without Using a Heat Pump

A geothermal heating and cooling system without using a heat pump is a direct method of utilizing the Earth's natural temperature to maintain comfortable indoor conditions without the mechanical compression and expansion processes that a traditional heat pump uses. In such a system, heat exchange occurs naturally between the building and the ground, using the stable temperature of the Earth as the source for heating and cooling. A ground-coupled heat exchanger is an underground heat exchanger that can capture heat from the ground and can also dissipate heat to the ground. A Ground Coupled Heat Exchanger is a cheaper and greener alternative of evaporative cooler and air conditioning system. They use the Earth's near-constant subterranean temperature to warm or cool air or other fluid for residential, agricultural, or industrial uses. It is a type of renewable energy system that usually exchanges heat with the ground or earth rather than the ambient air (Atmospheric air in the neutral state). As we all know that the temperature of the ambient air fluctuates throughout the year but in case of the ground the temperature of the ground at a certain depth stays relatively constant (nearly around 20ᵒ-25ᵒC) throughout the year all around the globe.

The system consists of the following parts i.e. air filter (4), water reservoir (2), water pump (3), cooling coils (5), fan (6), AC cooler motor (6), and HDPE pipes (1) as shown in the Figure. (Prateek Mahapatra and Shivam Singh) used the system for air conditioning a room, they found that the system can maintain the room temperature at 25°C while the surrounding temperature was 45°C



Bakhtiyar Ahmed Ali
Assistant Lecturer

Numerical Groundwater Modeling

Numerical Simulation Models (NSMs) are powerful tools that provide information for sustainable groundwater management and forecasting the effects of management measures. NSMs simplify complex hydrogeological systems, making it easier to investigate specific phenomena or forecast future groundwater and aquifer behaviour as shown in figure 1. In recent years, groundwater models have become essential tools for assessing water resources and protecting and restoring them. These models are helpful because they can simulate groundwater quantity and quality using holistic and multidisciplinary approaches. They can also project conditions and analyse future management and prediction scenarios.

Pshtiwan Othman Zaid
Assistant Lecturer

Balancing Small Ponds and Large Dams: A Sustainable Water Management Strategy for the Kurdistan Region

In the Kurdistan Region, the construction of over 100 small ponds with capacities not exceeding 500,000 cubic meters provides essential water resources for local communities, supporting domestic use, livestock, and small-scale irrigation. These ponds are vital for remote areas, offering accessible and cost-effective water storage solutions with minimal environmental impact. However, their limited capacity restricts their ability to address broader regional needs, such as large-scale irrigation, urban water supply, and energy generation. In contrast, large dams have the potential to bring transformative benefits to the region. They can store vast amounts of water, enabling large-scale irrigation projects that enhance agricultural productivity and food security, while also providing a reliable water supply for urban and industrial areas. Additionally, large dams can generate hydroelectric power, contributing to energy independence and supporting economic growth. However, large dams involve significant financial costs, extended construction timelines, and environmental and social challenges, such as community displacement and ecosystem disruption. To balance these considerations, a hybrid approach may be the most effective strategy. Small ponds should continue to be developed in rural areas to meet localized needs, while strategically placed large dams can address regional challenges, ensuring broader access to water resources and electricity. An integrated water resource management (IWRM) framework could optimize this balance, ensuring sustainable, equitable, and efficient use of water resources. This approach would enable the Kurdistan Region to meet immediate needs while fostering long-term economic and environmental resilience.