DEFORMATION ANALYSIS FOR TREATED SOIL USING PLAXIS

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Abstract : This paper presents a comprehensive review of deformation analysis for treated soil by utilizing PLAXIS software. Treated Soil, commonly referred to as improved ground, undergoes various stabilization techniques to enhance its engineering properties, including compaction, chemical stabilization and reinforcement. Plaxis is a software program widely used in geotechnical applications for the analysis of the analysis of load & deformations and etc. This software can represent the field properties of the soil into numerical analysis most accurately. And analyzing the behaviour of treated soil under different loading conditions. Particularly, while doing the soil stabilizations with additives and geosynthetic materials. The design parameters for the soil model are taken from the literature review to analysis the detailed geotechnical applications. The validity of using such values of Plaxis analysis will be confirm by a comparison of the resultant diagrams with field analysis.

Index Terms – Deformation analysis, Treated soil, PLAXIS, Stabilization techniques, Compaction.

1. INTRODUCTION

Soil is a dynamic and multifaceted resource that is essential for sustaining life on Earth. Its importance extends far beyond its role as a substrate for plants, encompassing functions critical to the health of ecosystems and the well-being of human societies. Recognizing the significance of soil and implementing sustainable soil management practices are essential for preserving this valuable resource for future generations.

Soil, often overlooked in its significance for construction, holds within its depths the foundation upon which infrastructure and human attempt stand. This unassuming blend of minerals, water, air, and organic matter serves as the bedrock for engineering feats, including the drilling of boreholes essential for construction projects. Beyond its role in supporting life, soil emerges as a critical element in the built environment, providing both the canvas and the challenge for construction attempt.

At its essence, soil is a canvas upon which the stories of geological processes and environmental dynamics unfold. From the slow weathering of parent materials to the sedimentary deposits shaped by millennia of natural forces, soil embodies the history and character of the land. Each layer tells a tale of compaction, erosion, and deposition, offering clues to the engineering challenges and opportunities that lie beneath the surface.

In the realm of construction, soil takes center stage as both a medium and a barrier to progress. In the context of borehole drilling, soil properties such as texture, moisture content, and compaction play a decisive role in determining drilling techniques, equipment requirements, and project timelines. Engineers must navigate the complexities of soil mechanics, grappling with issues of stability, bearing capacity, and soil-fluid interactions, to ensure the success of borehole operations.

Moreover, soil serves as a silent partner in the quest for sustainable infrastructure and environmental stewardship. Through geotechnical investigations and soil testing, engineers gain insights into soil behavior and site conditions, enabling informed decision-making and risk mitigation strategies. By harnessing the natural properties of soil, construction projects can minimize environmental impact, optimize resource utilization, and enhance resilience to geological hazards.

Water, too, emerges as a formidable force in the realm of borehole construction, posing challenges of infiltration, pore pressure, and groundwater contamination. Engineers must carefully assess soil permeability, hydrogeological conditions, and water table fluctuations to safeguard borehole integrity and prevent environmental contamination. Through the implementation of groundwater monitoring systems and well casing designs, construction projects can mitigatethe risks posed by watering and ensure the long-term sustainability of borehole infrastructure. Furthermore, soil serves as a repository of historical memory, bearing witness to the evolution of human settlements and land use practices. Archaeological surveys and soil stratigraphy offer insights into past civilizations, providing context for contemporary construction endeavors and cultural heritage preservation efforts. By integrating archaeological considerations into construction planning and site management, engineers can foster a deeper appreciation for the interconnectedness of human history and the built environment.

In essence, soil emerges as a dynamic partner in the construction process, offering both challenges and opportunities for engineering innovation and environmental stewardship. Its preservation and sustainable management are essential for ensuring the longevity and resilience of infrastructure projects, safeguarding the legacy of human ingenuity for generations to come. As custodians of the land, it falls upon us to approach soil with reverence and respect, recognizing its pivotal role in shaping the built environment and sustaining the foundations of civilization.

2. LITERATURE REVIEW

Vertical displacement reduction of cohesionless overburden soil by nails in box jacking. Kanwar Singh, Satyendra Mittal & Kishor Kumar-This journal deals with the challenge of constructing tunnels under already bustling urban areas It's crucial to keep the ground stable during construction to prevent any damage to the structures above. The common issue during tunnel construction is the potential for the ground to sink unevenly, which can cause all sorts of problems. To control this, the researchers explored a method called "soil nailing." Essentially, it involves reinforcing the soil with steel nails to add extra support and stability. They conducted experiments in a lab where they simulated digging a tunnel and observed how the ground reacted with and without soil nailing. What they found was pretty promising: when they used the steel nails, the ground above the tunnel didn't sink as much. It was a significant improvement in stability compared to not using soil nailing.

To make sure their findings were reliable, they also used computer models to simulate different scenarios. These models confirmed that soil nailing indeed reduced ground movement during tunnel construction.

Sen & Mishra (2010) reviewed the possibilities of using industrial wastes and by-products such as fly ash, blast furnace slag, cement kiln dust, waste foundry sand, phospogypsum, waste plastic bags and colliery sand for the construction of village roads. The authors report that use of these materials improves the engineering properties of the soil and hence suitable to be used for village road construction. Swamy & Das (2012) have explored the possibility of using industrial wastes such as fly ash, waste glass, construction demolishes, colliery spoil, slag, foundry sand and kiln dust. They conclude that there is ample scope for using these materials for road construction but with the caution to ensure that the use of industrial wastes and by-products does not produce health hazards. Guney et al. (2006) have carried out laboratory experiments on soil- WFS mixtures to test their strength parameters and hence their suitability to be used as highway sub-base materials. Cement and lime were used in their study as stabilization materials. The considered mixture proportions were compacted at different moisture contents and different compactive efforts in the laboratory. Tests such as unconfined compression, California bearing ratio, and hydraulic conductivity tests were carried out. Hydraulic conductivity tests on the effluent collected were used to evaluate the environmental suitability of the mixture proportions. Leaching tests indicated that if the soil-WFS mixtures come in contact with water, the quality of water will not be affected.

IRC 37 (2012) provided the description about IITPAVE. Sub-base thicknesses were finally determined using the laboratory-based strength parameters and IITPAVE. Any combination of traffic and pavement layer composition can be tried using IITPAVE. The traffic volume, number of layers, the layer thickness of individual layers and the layer properties are the user specified inputs in the Program. A satisfactory pavement design is achieved through iterative process by varying layer thicknesses or, if necessary, by changing the pavement layer materials. Lav & Lav (2014) have carried out repeated load indirect tensile and repeated load triaxial tests to investigate the effects of stabilization on the resilient behavior of fly ash to be used as pavement material for highway construction. They reported that stabilization of fly ash is important when it is used in the upper layers of the pavement. Kalkan(2006) has reported the results of the investigation carried out on red mud for useful purpose. The use of red mud for the stabilization material was investigated. This study pertains to study the effects of using red mud on the stabilization of soil. Unconfined compressive strength, hydraulic conductivity, and swelling were determined through experimental study. They report that compacted clay samples containing red mud and cement–red mud additives have a high compressive strength. They also report that the hydraulic conductivity and swelling percentage decrease compared to natural clay samples.

From the literature survey it is clear that there is a wide scope for using the industrial wastes and by-products in highway construction. Waste foundry sand, fly ash and red mud are reported to improve the engineering properties of the soil and hence might form suitable alternative materials to virgin materials. Some of the researchers have also noted that use of stabilizing materials such as lime or cement is necessary for achieving better geotechnical strength parameters.The research studies also report that the industrial by-products and wastes if used do not contaminate the water that seep into the ground and percolate through the ground water. In general it is very clear that the industrial by-products and wastes such as waste foundry sand, fly ash and red mud may be considered as a material to be used for construction. With respect to our country India, there is a lot more is needed for new construction of highways and repairing of existing damaged highways. And hence, use of industrial by-products and wastes for construction of highways may thus form an excellent space for utilizing them without being dumped or disposed on the vacant land thereby polluting the environment. Thus use of industrial by-products and wastes will lead to achieve sustainable development.

3. METHODOLOGY

The methodology provides a systematic framework for soil analysis. It guides the process of understanding soil properties and their implications for engineering projects. Following this method ensures thorough, accurate, and well-documented analyses, leading to informed decisions and successful project outcomes

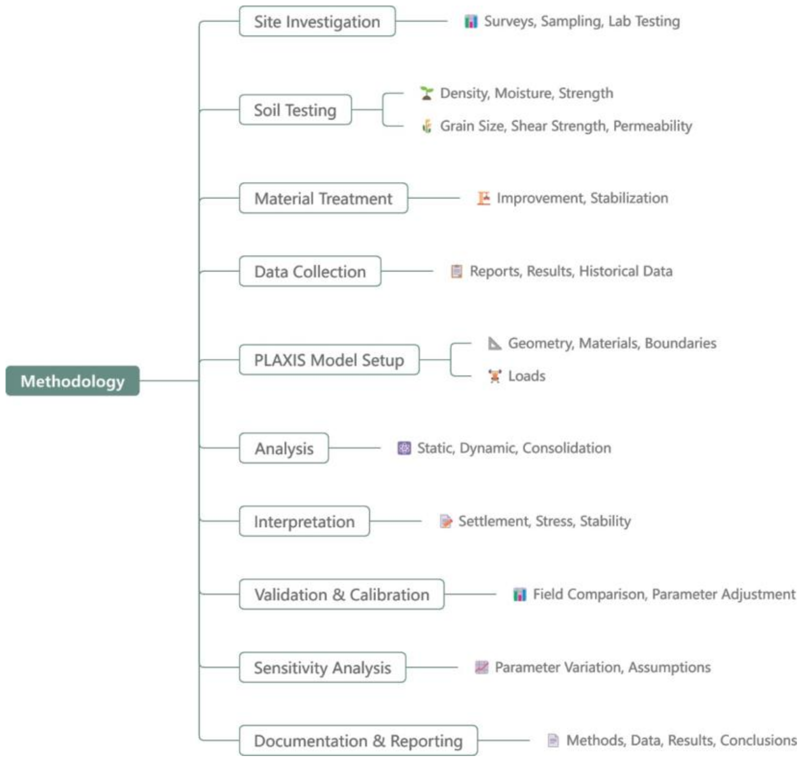

Fig.1 Methodology

Geotechnical Site Investigation:

This phase involves conducting detailed field surveys to assess the geological and geotechnical characteristics of the site. Surveys may include geological mapping, topographic surveys, and geophysical investigations to identify potential hazards or anomalies. Soil sampling involves collecting representative samples from various depths for laboratory testing. Perform sieve analysis to determine the particle size distribution of the soil at the site. Consider the results of the sieve analysis when selecting appropriate soil models and parameters for the PLAXIS model setup.

Soil Testing:

Soil testing is crucial in engineering projects, providing vital data for design and construction. It includes various tests, like the California Bearing Ratio (CBR) test, which checks soil strength for pavement design. Shear tests assess soil resistance to deformation, while sieve analysis determines grain size distribution, affecting permeability and compaction. Moisture content tests measure water levels, density tests evaluate compaction, and Atterberg limits test soil plasticity. These tests help understand soil behaviour and guide decision-making in construction.

Material Treatment:

This stage involves implementing measures to improve or stabilise the soil's properties to meet engineering requirements. Methods may include compaction, chemical stabilisation, or reinforcement with geosynthetic materials or structures Use the data collected from the site investigation to input the material properties into the PLAXIS model.

Adjust the soil parameters based on the sieve analysis results to accurately represent the soil behavior under loading.

Analysis Type and Settings:

Select the appropriate analysis type in PLAXIS, considering factors such as static or dynamic loading and linear or nonlinear behavior. Configure the analysis settings, including convergence criteria and solution methods, to ensure accurate and efficient analysis results.

Loading Conditions:

Apply loading conditions to the model based on the expected service and ultimate loads. Consider seismic loading if applicable, and incorporate dynamic analysis techniques if necessary.

Data Collection:

Gather all relevant data from the geotechnical site investigation, including soil test results, borehole logs, and laboratory reports. Ensure that the sieve analysis results are included in the dataset for an accurate representation of soil properties.

Boundary Conditions:

Define appropriate boundary conditions based on the expected loading and soil-structure interaction. Consider factors such as groundwater conditions and lateral constraints when specifying boundary conditions in PLAXIS.

PLAXIS Model Setup:

Use the results of the geotechnical site investigation to define the geometry and material properties of the model. Incorporate the ASE method for axisymmetric equilibrium analysis, especially for footing designs where symmetry can be assumed. Implement the soil parameters obtained from laboratory testing, taking into account the particle size distribution determined through sieve analysis. Using finite element software like PLAXIS, engineers define the soil-structure system's geometry, material properties, and boundary conditions for simulation. Analysis settings are also specified.

Analysis: The PLAXIS model simulates the soil-structure system's behaviour under various loading conditions, including static, dynamic, and consolidation analyses.

Interpretation of Results:

Interpret the results of the PLAXIS analysis to assess factors such as settlement, bearing capacity, and stability. Compare the computed results with relevant design codes and standards to ensure compliance with safety requirements. Engineers analyse PLAXIS results to understand settlement, stress distribution, and stability of the soil-structure system.

Validation and calibration:

Validate the PLAXIS model against field observations and empirical data.Calibrate the model parameters, if necessary, to improve the accuracy of the predictions. Results from PLAXIS analysis are compared to field measurements or benchmarks to ensure accuracy. Model parameters may be adjusted for improved correlation with observed behaviour.

Sensitivity Analysis:

Perform sensitivity analysis to evaluate the influence of key parameters on the model response. Assess the sensitivity of the results to variations in soil properties, loading conditions, and modeling assumptions. Engineers assess the impact of parameter variations on model results to identify critical factors influencing system behavior Documentation and Reporting:

Document all aspects of the geotechnical site investigation and PLAXIS model setup, including data collection procedures, analysis methodologies, and result interpretation. A comprehensive report documenting methodologies, assumptions, data, results, and conclusions is prepared to communicate findings and recommendations transparently to stakeholders. It serves as a valuable reference for future projects and supports peer review and quality assurance processes. Prepare a comprehensive report summarizing the findings, recommendations, and any limitations or uncertainties associated with the analysis.

4. RESULTS AD DISCUSSIONS

This document presents the findings of a study focused on the analysis of rigid footings using PLAXIS software. The study aims to investigate the behavior of rigid footings under various loading conditions, leveraging material properties obtained from literature reviews. Rigid footings are integral components of structural foundations, tasked with supporting buildings, bridges, and other infrastructure under significant loads and soil pressures.

The analysis conducted in this study utilizes PLAXIS software, a powerful tool for simulating soil-structure interactions through finite element analysis. By incorporating material properties sourced from literature, including parameters such as soil stiffness, strength, and deformation characteristics, the PLAXIS models accurately represent real-world conditions.

Through a systematic approach, the study examines the response of rigid footings to different loading scenarios, including static and dynamic loads. Factors such as settlement, bearing capacity, and structural stability are evaluated to assess the performance of the footings under various conditions.

The findings presented in this document provide valuable insights into the behavior of rigid footings and their interaction with underlying soil layers. These insights are essential for informing engineering design decisions and optimizing the performance of foundations in geotechnical engineering practice. The case results presented herein contribute to the body of knowledge in the field of geotechnical engineering and serve as a valuable resource for practitioners and researchers alike.

In addition to analyzing the behavior of rigid footings, this study also aims to contribute to the advancement of geotechnical engineering methodologies. By utilizing material properties obtained from literature reviews, the study demonstrates the importance of thorough data collection and analysis in the design and analysis of structural foundations. The findings presented herein not only provide practical insights into the performance of rigid footings but also underscore the significance of integrating empirical data with advanced modeling techniques. Furthermore, the methodologies employed in this study serve as a framework for future research endeavors, offering guidance on how to effectively utilize PLAXIS software and literature-derived material properties in the analysis of geotechnical systems. Through continued research and collaboration, the field of geotechnical engineering can further refine its understanding of soil-structure interactions and enhance the design and construction of resilient infrastructure systems.

Experimental Investigation of free head model piles under lateral load in homogenous and layered sand Result Analysis:

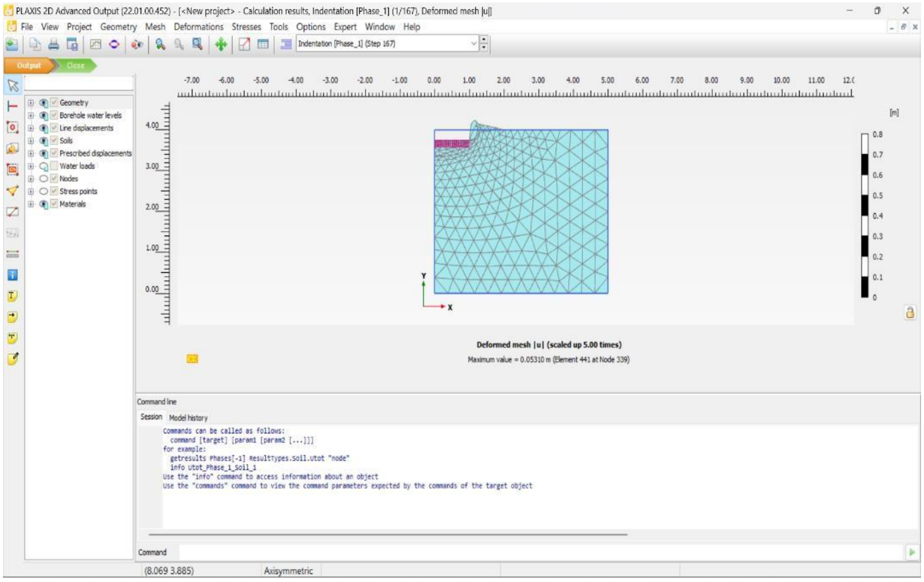

Fig 2. Deformed Mesh

This finding demonstrates that when a load is exerted onto the surface, the soil reacts by undergoing either excavation or displacement. The load's impact prompts a reaction from the underlying soil layers, resulting in the movement or removal of soil material. This excavation process unfolds as the load is transferred to the soil, inducing deformation or displacement. Grasping the soil's response to loading is pivotal in engineering applications, given its direct influence on the stability and functionality of structures erected on or in contact with the soil.

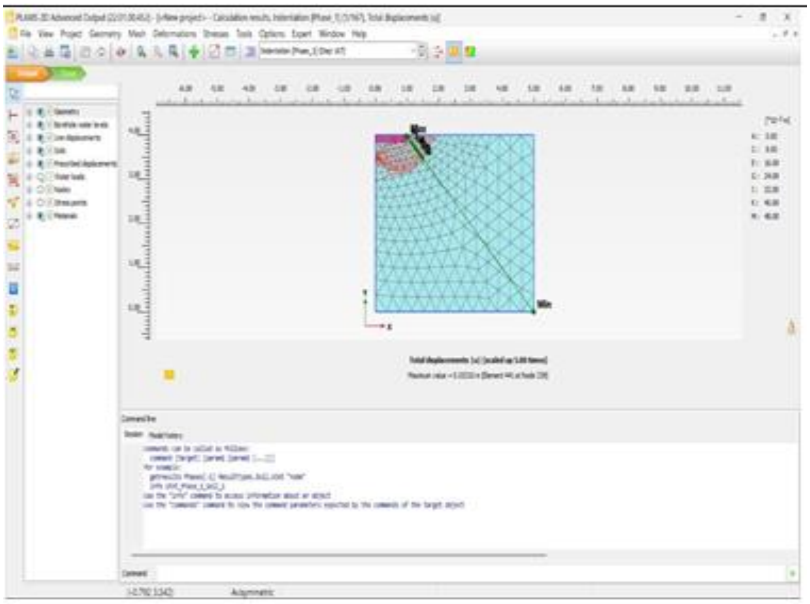

Fig 3. Total Displacement

The contour lines are depicted in red, with green lines indicating scale measurements. These contour lines delineate areas of uniform elevation or depth beneath the surface, mirroring a topographic map of the soil. Each contour line is labeled with its corresponding elevation or depth level. Engineers rely on these lines to discern variations in soil composition, such as alterations in thickness or the presence of distinct soil layers. This understanding is essential for project planning and identifying potential obstacles in construction endeavors. Ultimately, contour lines offer a graphical depiction of subsurface terrain, facilitating the interpretation and application of geotechnical data.

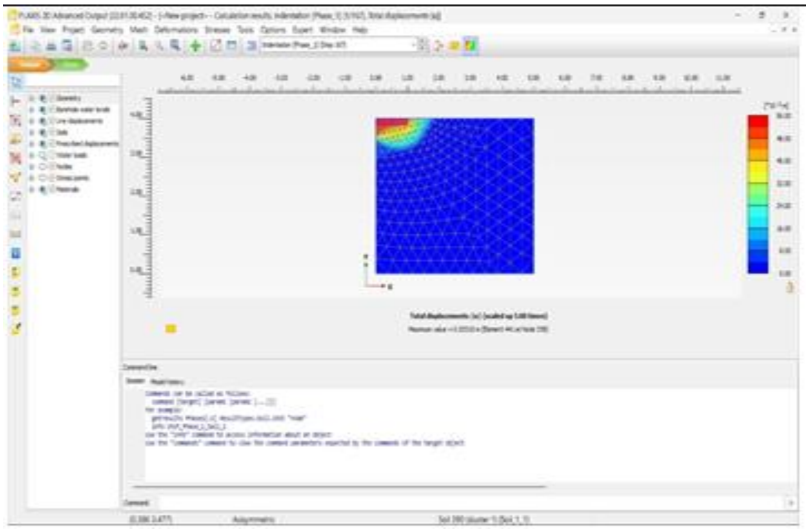

Fig 4.10 Phase Displacement

The deformation is depicted through holographic representation, where colour variations indicate the direction and magnitude of the soil's displacement or movement due to the applied load. Darker hues signify areas of significant deformation, while lighter shades represent less displacement. This holographic visualization method highlights zones of potential concern for engineers, allowing them to assess the extent of soil deformation and identify areas requiring attention or further investigation. By analyzing this holographic representation, engineers gain insight into how the soil responds to external loads, enabling them to make informed decisions regarding design adjustments or structural reinforcements to ensure stability and safety in geotechnical projects.

5. CONCLUSIONS

In conclusion, this paper provides a comprehensive review of deformation analysis for treated soil utilizing PLAXIS software, with a particular focus on improved ground subjected to various stabilization techniques such as compaction, chemical stabilization, and reinforcement. PLAXIS software emerges as a powerful tool widely employed in geotechnical applications for analyzing load-deformation behaviors with high precision. The software effectively represents field properties of soil into numerical analysis, allowing engineers to accurately predict the behavior of treated soil under different loading conditions, especially during soil stabilizations involving additives and geosynthetic materials.

The design parameters for the soil model are meticulously derived from a thorough literature review, ensuring the analysis's accuracy and reliability in reflecting real-world scenarios. By employing PLAXIS, engineers can simulate detailed geotechnical applications, providing insights into the performance of treated soil and the effectiveness of various stabilization methods.

One significant aspect emphasized in this study is the validation of PLAXIS analysis results through comparison with field analyses. This validation process ensures that the values obtained from PLAXIS simulations align closely with actual field observations, enhancing the confidence in using PLAXIS for geotechnical analyses.

Moreover, the inclusion of rigid footing conditions adds another layer of complexity to the analysis, allowing for a more comprehensive understanding of soil behavior and its interaction with structural elements. The incorporation of rigid footing conditions enables engineers to assess the stability and performance of structures built on treated soil accurately.

In summary, this paper underscores the importance of employing advanced numerical tools like PLAXIS for deformation analysis of treated soil. Through rigorous validation and meticulous parameter selection, PLAXIS facilitates accurate prediction of soil behavior and enhances the efficiency and reliability of geotechnical design and analysis processes. The insights gained from this study contribute to the advancement of geotechnical engineering practices, ultimately leading to safer and more resilient infrastructure development.

REFERENCES

1. K. Mahesh Bhat , Sitaram Nayak “Experimental Studies and its Application using PLAXIS-2D for Lithomargic Clay Stabilized by GBFS and Lime” Under exclusive licence to Springer Nature Switzerland AG 2021
2. Mohammad Sadik khan, S.M. ASCE; MD. Sahadat Hossain, P.E., M. ASCE; Nicasio Lozano, P.E. “ A Numerical Study on slope stabilization using Recycled Plastic Pin”.
3. Aqeel AI-Adili & N. Sivakugan “ Numerical model to predict the settlement response of two nearby foundations due to geotextile slippage”. International Journal of Geotechnical Engineering, 2:4,441-453, DOI: 10.3328/IJGE.2008.02.04.441-453.
4. R. Acharyya & A. Dey “ Assessment of bearing capacity and failure mechanism of single and interfering strip footings on sloping ground”. International Journal of Geotechnical Engineering.
5. Gregor Vilhar , Anita Laera, Federico Foria, Abhishek Gupta and Ronald B. J. Brinkgreve. “Implementation, Validation, and Application of PM4S and Model in PLAXIS”.
6. Shadi Aria, Sanjay Kumar Shukla & Alireza Mohyeddin. “ Optimum burial depth of geosynthetic reinforcement within sand bed based on numerical investigation”. International Journal of Geotechnical Engineering, DOI: 10.1080/19386362.2017.1404202.
7. Waleed Abdullah, Ananth Ramasamy, Ahmad Talaat & Srour Alotaibi “ Verification of the preloading design of soft clay with prefabricated vertical drains by full-scale field instrumentation and numerical modelling”. International Journal of Geotechnical Engineering, DOI: 10.1080/19386362.2018.1513674.
8. Rana Acharyya, Arindam Dey & Bimlesh Kumar. “ Finite element and ANN-based prediction of bearing capacity of square footing resting on the crest of c- pie soil slope” International Journal of Geotechnical Engineering, DOI: 10.1080/19386362.2018.1435022.
9. S. A. Mangi, Z. A. Memon, S. H. Khahro, R. A. Memon, and A. H. Memon, “Potentiality of industrial waste as supplementary cementitious material in concrete production,” International Review of Civil Engineering (IRECE), vol. 11, no. 5, pp. 214–221, 2020.
10. B. George, C. Lexander, and G. Hari, “Investigation on multi under reamed piles with small bulb diameter in clay,” International Journal of Geotechnical Engineering, vol. 16, no. 4, pp. 462–470, 2022.
11. W. Yang, J. Liu, and S. Gao, “Experimental study on the thermal conductivity of aerogel-enhanced insulating materials under various hygrothermal environments,” Energy and Buildings, vol. 206, no. Jan, pp. 1–14, 2020.
12. I. P. Okokpujie, “Experimental analysis of cutting force during machining difficult to cut materials under dry mineral oil and tio2 nano-lubricant,” Journal of Measurements in Engineering, vol. 9, no. 4, p. 13, 2021.
13. Y. Ming, P. Chen, L. Li, and G. Pan, “A comprehensive review on the utilization of recycled waste fibers in cement-based composites,” Materials, vol. 14, no. 13, p. 3643, 2021.
14. A. A. Erbnoiu, C. M. Grdinaru, N. Cimpoeu, D. Filipeanu, B. V. Erbnoiu, and N. C. Chereche, “Study of an ecological cement-based composite with a sustainable raw material sunflower stalk ash,” Materials, vol. 14, no. 23, p. 7177, 2021.
15. N. Chernysheva, V. Lesovik, and N. Vatin, “Improvement of performances of the gypsum-cement fiber reinforced composite (gcfrc),” Materials, vol. 13, no. 17, p. 3847, 2020.
16. C. Bopda Fokam, E. Toumi, B. Kenmeugne, N. C. Wiryikfu, and L. Mevaa, “Experimental study of the addition of oil palm mesocarp fiber on the physical and mechanical properties of fiber cement mortar composites,” SN Applied Sciences, vol. 3, no. 1, pp. 1–8, 2021.
17. Abu-Farsakh, Murad, Qiming Chen, and Radhey Sharma. (2013). “An Experimental Evaluation of the Behavior of Footings on Geosynthetic Reinforced Sand.” Soils and Foundations, 53(2), 335–348.
18. Abu-Farsakh, Murad Yusuf, Qiming Chen, and Sungmin Yoon. (2008). Use of Reinforced Soil Foundation (RSF) to Support Shallow Foundation. Baton Rouge, LA: Louisiana Transportation Research Center.
19. Alston, C., D. K. Lowry, and A. Lister. (2015). “Geogrid Reinforced Granular Pad Foundation Resting on Loose and Soft Soils, Hamilton Harbour, Ontario.” International Journal of Geosynthetics and Ground Engineering, 1(3), 21.