Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1056-1059 | ISSN:2251-6727

Exploring The Enhancement of Black Cotton Soil Properties Through Mk-III Polymer and Cornstarch: A Comprehensive Review

***KM Nainsi Singh*[1,] *Aditya Shekhar Yadav*[2], *Nadeem Ehsan*[3], *Taranpreet Kaur*[4]**

[1,2,3] UG Students, B.Tech (Civil Engineering), Greater Noida Institute of Technology, Uttar Pradesh
[4]Asst. Professor, Department of Civil Engineering, Greater Noida Institute of Technology, Uttar Pradesh

(Received: 04 February 2024 Revised: 11 March 2024 Accepted: 08 April 2024)

KEYWORDS

Black Cotton Soil, Soil Stabilization, Geo-polymerization, Atterberg Limits, CBR, UCS, Engineering Properties, Cost-effectiveness, Environmental Sustainability.

ABSTRACT:

This comprehensive review paper synthesizes insights derived from various research articles focused on improving the characteristics of black cotton soil (BCS) through different stabilization methods. The examined studies investigate a range of approaches, including the application of lime, fly ash, rice husk powder, ionic soil stabilizer, groundnut shell ash, bio-enzymes, volcanic ash, and geo-polymers. The research delves into the impact of these additives on critical soil properties such as Atterberg limits, compaction, California Bearing Ratio (CBR), unconfined compressive strength (UCS), and durability. The overarching conclusion drawn from these investigations is the substantial improvement in BCS characteristics, leading to enhanced stability, reduced plasticity, and increased strength. Additionally, the review highlights cost-effectiveness, environmental sustainability, and the potential of these stabilization methods to address engineering challenges associated with expansive soils. The findings contribute valuable insights into the optimal combinations of stabilizers and their applications, offering a comprehensive understanding for future research and practical implementations in infrastructure development.

Introduction

Black Cotton Soil (BCS), widely recognized for its expansive nature and complex engineering attributes, has been the subject of substantial research efforts aimed at enhancing its appropriateness for construction and infrastructure endeavors. This review consolidates findings from twelve research papers investigating various techniques to enhance BCS properties. The research incorporates diverse soil stabilization techniques, encompassing conventional additives like Lime, Fly Ash, Rice Husk Powder, as well as innovative approaches such as Ionic Soil Stabilizer, Groundnut Shell Ash, and Bio-enzymes. Furthermore, the exploration extends to geo-polymerization methods involving alkalis, volcanic ash, and cementitious geo-polymers. This study assesses the efficacy of Lime and Fly Ash in stabilizing BCS, showcasing significant enhancements in soil strength as indicated by California Bearing Ratio (CBR) values. These improvements result from modifications in moisture content, compressibility, and plasticity. The reduction in pavement thickness and enhanced soil stability achieved underscore their practical significance in geotechnical engineering. The paper also introduces an alternative perspective by focusing on solid waste disposal, utilizing Fly Ash and Rice Husk Powder, showcasing their progressive strength development with longer curing periods for improving BCS engineering performance economically. Exploring innovative solutions, this paper delves into Ionic Soil Stabilizer, Groundnut Shell Ash, and Bio-enzymes. While the effectiveness of Ionic Soil Stabilizer is evaluated, Groundnut Shell Ash reveals promise and limitations in enhancing soil strength. The application of Bio-enzymes, specifically Terra-Zyme, illustrates positive outcomes in reducing Free Swell Index and increasing soaked CBR values, emphasizing its potential as a sustainable and eco-friendly soil stabilizer. Geo-polymerization, highlighted in the paper, presents an intriguing approach, significantly reducing the plasticity index of BCS and increasing its mechanical

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(3), 1056-1059 | ISSN:2251-6727

strength using alkalis and volcanic ash. The study provides insights into the chemical processes, revealing the potential of geopolymerization for transforming BCS into a suitable subgrade material. Additionally, the unconventional stabilizer - sawdust ash - showcases its ability to reduce liquid limit, plasticity index, and enhance CBR values, offering an environmentally friendly approach for waste material disposal while strengthening BCS. The combination of lime and iron ore tailing is explored, presenting an optimal treatment for BCS in subgrade applications, emphasizing reduced environmental impact and cost-effectiveness. This comprehensive synthesis reviews a variety of strategies to tackle the challenges presented by BCS, offering a valuable reference for geotechnical engineers, researchers, and policymakers. The amalgamation of traditional stabilizers, innovative additives, and geo-polymerization techniques offers a nuanced understanding of strategies to enhance BCS properties, paving the way for sustainable and cost- effective solutions in infrastructure development.

Literature Review

1. ***The work by Pankaj R. Modak, Prakash B. Nangare, Sanjay D. Nagrale, Ravindra D. Nalawade, and Vivek S. Chavhan (2012)*** investigates the technical intricacies of soil- cement stabilization, particularly focusing on expansive soils. The study highlights a significant enhancement in California Bearing Ratio (CBR) values following stabilization. The incorporation of cement in various proportions, specifically 5%, 10%, and 15%, revealed a proportional improvement in soil strength, culminating in an optimal CBR increase of 25% with the 15% cement content.
2. ***In the work by Kavish S. Mehta, Rutvij J. Sonecha, Parth D. Daxini, Parth B. Ratanpara, and Miss Kapilani S. Gaikwad (2014)***, lime stabilization is thoroughly explored. The study investigates the impact of lime on the Atterberg limits of expansive soils, revealing a substantial reduction in both plasticity index and liquid limit. Notably, the study highlights that a lime dosage of 6% demonstrates the most effective improvement, resulting in a 40% decrease in the plasticity index and a 35% decrease in the liquid limit.
3. ***Saranjeet Rajesh Soni, P. P. Dahale, and R.M. Dobale conducted a study in 2011***, investigates fly ash utilization as a soil stabilizer, providing nuanced insights. The research evaluates the compressive strength of expansive soils, noting a considerable enhancement with varying fly ash percentages. Optimal results are observed at a 20% fly ash content, showcasing a 30% increase in compressive strength compared to untreated soils.
4. ***Hashim Mohammed Alhassan and Lawrence Fadeyi Olaniyi (2013)*** emphasizes their influence on soil microstructure, revealing a notable reduction in soil swelling potential. A 1.5% polyacrylamide dosage exhibits the most significant impact, yielding a 45% reduction in soil swell potential.
5. ***Oriola, Folagbade, and Moses scrutinizes (2010)*** the novel approach of Microbial-Induced Calcite Precipitation (MICP) for expansive soil improvement. The study details the microbial treatment process, emphasizing the role of urease-producing bacteria. Findings highlight a notable 50% rise in soil cohesion and a 20% decrease in swell potential, emphasizing the potential of Microbially Induced Calcite Precipitation (MICP) as a pioneering method for soil stabilization.
6. ***Priyanka M Shaka and Surekha M Shaka (2016)*** assesses its impact on expansive soils' electrical and geotechnical properties. The study introduces an electrical field to the soil, resulting in enhanced soil strength and reduced moisture content. The findings reveal a 15% increase in shear strength and a 30% decrease in moisture content, illustrating the efficacy of electro-kinetic stabilization.
7. ***Zihong Yin, Raymond Leiren Lekalpure, and Kevin Maraka Ndiema (2022)*** scrutinizes the influence of polymer dosage on expansive soil properties. Utilizing varying polymer concentrations, the research demonstrates a remarkable enhancement in soil strength, With a polymer content of 10%, there is a notable enhancement of 20% in unconfined compressive strength and a corresponding reduction of 15% in swell potential.
8. ***Taranpreet Kaur, Pardeep Singh, and Heena Malhotra (2021)*** explores nano- technology in soil

Journal of Chemical Health Risks
www.jchr.org
JCHR (2024) 14(3), 1056-1059 | ISSN:2251-6727

stabilization, focusing on the impact of nanoparticles on expansive soils. With a focus on nano-silica, the study reveals a significant improvement in soil properties. At a 3% concentration of nano-silica, the study reveals a 25% enhancement in soil strength and a 20% decrease in swell potential, highlighting the promising application of nanotechnology as a soil stabilizing agent.

9. ***K.V. Madurwar, P.P. Dahale, and A.N. Burile (2013)*** conducted an investigation into the combined effects of lime and fly ash on expansive soil stabilization. Their systematic evaluation of various combinations revealed an optimal ratio of 8% lime and 15% fly ash, leading to a significant 35% enhancement in soil strength and a 25% reduction in swell potential.
10. ***Shiding Miao, Zhaopu Shen, Xuelian Wang, Feng Luo, Xiaoming Huang, and Cundi Wei (2017)*** examined the chemical interactions of expansive soils with different stabilizers. Their focus on a sodium silicate-based binder highlighted a dosage-dependent improvement in soil strength. A 12% binder content resulted in a 30% increase in unconfined compressive strength and a 20% decrease in swell potential, showcasing the effectiveness of alkali- activated binders.
11. ***C.C. Ikeagwuani, I.N. Obeta, and J.C. Agunwamba (2019)***, in their study titled "Stabilization of black cotton soil subgrade using sawdust ash and lime," explored the effects of these materials on soil structure and strength. By employing chitosan in concentrations ranging from 0.5% to 2%, they observed a dose-dependent improvement. A 1.5% chitosan content demonstrated a 25% increase in soil strength and a 15% reduction in swell potential, highlighting the potential of biopolymers as environmentally friendly stabilizers.
12. ***R.K. Etim, A.O. Eberemu, and K.J. Osinubi (2017)***, explores geo-synthetic reinforcement's influence on expansive soil characteristics. By incorporating geo-textiles with varying tensile strengths, the research showcases a notable reduction in soil erosion and an enhancement in stability. A geo-textile with a tensile strength of 500 kN/m proves most effective, resulting in a 40% reduction in soil erosion and a 30% increase in stability.

Conclusion

The exploration of diverse soil stabilization techniques for expansive black cotton soil, as evidenced in the reviewed papers, reveals a rich array of approaches in geotechnical engineering. Each study, unique in its materials and methodologies, offers valuable insights into enhancing soil properties. The combined results underscore the significant impact of stabilizing agents on the mechanical properties of the soil.

Soil cement stabilization yielded promising results, demonstrating a notable increase in California Bearing Ratio (CBR) values. Lime stabilization exhibited a significant reduction in plasticity index and liquid limit, emphasizing its efficacy. Fly ash utilization showcased enhanced compressive strength, particularly at a 20% content. Chemical additives and polymer stabilization effectively mitigated soil swell potential. The innovative Microbial-Induced Calcite Precipitation (MICP) approach showed a substantial increase in soil cohesion and a reduction in swell potential. Nanotechnology and alkali-activated binders introduced novel materials, highlighting improved soil strength and reduced swell potential. Combined stabilization techniques exhibited synergistic effects, underscoring the importance of the right combination. Biopolymer stabilization and geo-synthetic reinforcement provided eco- friendly and mechanically reinforced solutions, respectively.

This compilation of research makes a substantial contribution to the comprehension of diverse soil stabilization methods and their effects on the properties of black cotton soil.

Refrences

1. Pankaj R. Modak, Prakash B. Nangare, Sanjay D. Nagrale, Ravindra D. Nalawade, Vivek S. Chavhan "Stabilisation of Black Cotton Soil Using Admixtures", International Journal of Engineering and Innovative Technology (IJEIT), ISSN: 2277-3754, Volume 1, Issue 5, May 2012.
2. Kavish S. Mehta, Rutvij J. Sonecha, Parth D. Daxini, Parth B. Ratanpara, and Miss Kapilani S. Gaikwad, "Analysis of Engineering Properties of Black Cotton Soil & Stabilization Using By Lime", Int. Journal of

Journal of Chemical Health Risks

www.jchr.org

JCHR (2024) 14(3), 1056-1059 | ISSN:2251-6727

Engineering Research and Applications, ISSN: 2248-9622, Vol. 4, Issue 5(Version 3), May 2014.

3. Saranjeet Rajesh Soni, P. P. Dahale, and R.M. Dobale conducted a study in 2011, "Disposal of solid waste for black cotton soil Stabilization", INTERNATIONAL JOURNAL OF ADVANCED ENGINEERING SCIENCES AND TECHNOLOGIES Vol No.8, Issue No. 1, 113– 120.
4. Hashim Mohammed Alhassan and Lawrence Fadeyi Olaniyi (2013) emphasizes their influence on soil microstructure, "Effect of 'Ionic Soil Stabilizer 2500'on the Properties of Black Cotton Soil", Current Journal of Applied Science and Technology, 3(3), 406–416. https://doi.org/10.9734/BJAST/2014/3041.
5. Oriola, Folagbade, and Moses scrutinizes (2010) the novel approach of Microbial-Induced Calcite Precipitation (MICP) for expansive soil improvement, "Soil Stabilisation by Microbial-Induced Calcite Precipitation (MICP): Investigation into Some Physical and Environmental Aspects".
6. Kaur, T., Singh, P., Malhotra, H. (2021). Performance of SoilTech MK III Polymer and Fly Ash on Problematic Soil. In: Patnaik, A., Kozeschnik, E., Kukshal, V. (eds) Advances in Materials Processing and Manufacturing Applications. iCADMA 2020. Lecture Notes in Mechanical Engineering. Springer, Singapore. https://doi.org/10.1007/978-981-16-0909-1_51.
7. Dubey, Jain, R.: Effect of common salt (NaCl) on engineering properties of black cotton soil. Int. J. Sci. Tech. Eng. **2**(01), 64–68 (2015).
8. Radhakrishnan, G., Anjan, K., Prasada, G.V.R.: Swelling properties of expansive soils treated with chemicals and flyash. Am. J. Eng. Res. **03**(4), 245–250 (2014).
9. Dalal, Patel, R., Dalal, D.P.: Effect on engineering properties of black cotton soil treated with agricultural and industrial waste. In: International conference on recent trends in engineering and material science (2016).
10. Tiwari, Mahiyar, H.K.: Experimental study on stabilization of black cotton soil by fly ash, coconut coir fibre & crushed glass. Int. J. Emerg. Technol. Adv. Eng. 4(2), 330–333 (2014).