

e-ISSN: 2319-8753 | p-ISSN: 2347-6710

DIA

International Journal of Innovative Research in SCIENCE | ENGINEERING | TECHNOLOGY

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY

Volume 13, Issue 2, February 2024

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

Impact Factor: 8.423

9940 572 462

6381 907 438

 \bigcirc





e-ISSN: 2319-8753, p-ISSN: 2347-6710 www.ijirset.com | Impact Factor: 8.423 | A Monthly Peer Reviewed & Referred Journal |



|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

Stabilisation of Black Cotton Soil Using FGD Gypsum

Anusha S S^{1a}, Harshavardhan B S^{1b}, Impana A^{1c}, Sridhar H N²

UG Student, Dept. of Civil Engineering, Dayananda Sagar College of Engineering. Bangalore, Karnataka, India^{1abc}

Assistant Professor, Dept. of Civil Engineering, Dayananda Sagar College of Engineering. Bangalore,

Karnataka, India²

ABSTRACT: This study investigates the feasibility of using flue-gas desulfurization (FGD) gypsum as a stabilizing agent for black cotton soil, a challenging soil type common in various regions. Black cotton soil poses significant engineering challenges for construction projects due to its high flexibility, low bearing capacity, and susceptibility to swelling and shrinking. FGD gypsum, a by-product of coal-fired power plants, is selected for its abundance and potential ecological benefits. Through comprehensive laboratory testing, the study assesses the impact of FGD gypsum on the engineering properties of black cotton soil, including liquid limit, plastic limit, compaction and unconfined compressive strength, using different dosages of FGD gypsum. The primary objective is to determine the optimal dosage of FGD gypsum to enhance soil strength, decrease flexibility, and improve overall stability. This research offers a sustainable solution to the challenges of stabilizing black cotton soil in construction projects, promoting sustainable waste management practices and providing an economically and environmentally viable method for soil stabilization.

KEYWORDS: feasibility , stabilising, susceptibility

I. INTRODUCTION

The stabilization of black cotton soil is a critical aspect of geotechnical engineering and construction due to the challenges posed by this expansive soil type. Black cotton soil, known for its high shrink-swell potential, presents difficulties in foundation design and infrastructure development. Stabilization methods aim to enhance the engineering properties of this soil to mitigate issues related to soil expansion and contraction. These methods include modifying soil properties to improve bearing capacity, ensuring the durability of structures like buildings, roads, and bridges. Stabilization techniques offer cost-effective solutions by providing alternatives to expensive soil replacement or extensive foundation design alterations. Additionally, these methods contribute to environmental sustainability by repurposing waste materials and addressing concerns related to waste disposal and environmental impact. In agricultural areas, soil stabilization plays a crucial role in preventing soil erosion, maintaining soil structure, and enhancing agricultural productivity.

Ongoing research in soil stabilization techniques, including the use of novel additives and technologies, continues to expand the scope of addressing challenges associated with black cotton soil, showcasing the evolving nature of soil stabilization practices in the field of civil engineering.

Black cotton soil, also known as expansive clay soil, is a prevalent soil type found in various regions globally, particularly in semi-arid and tropical climates. Its unique characteristics, including high plasticity, swelling and shrinkage behavior, and low bearing capacity, present significant challenges for construction projects, roadways, and infrastructure development. The expansive nature of black cotton soil makes it susceptible to volumetric changes with changes in moisture content, leading to distress in built structures such as cracks in buildings, roads, and pavements.

Addressing the engineering challenges associated with black cotton soil is of paramount importance for sustainable development and infrastructure resilience. Various stabilization techniques have been proposed and implemented in order to enhance the black cotton soil's engineering qualities aiming to mitigate its detrimental effects and enhance its suitability for construction purposes. These techniques encompass a variety of strategies, such as chemical stabilisation, mechanical stabilization, and biological stabilization.

Chemical stabilization involves the addition of chemical admixtures such as lime, cement, fly ash, and bitumen to alter the soil's properties and enhance its strength and stability.

Lime stabilization, in particular, has been widely utilized due to its effectiveness in reducing plasticity, increasing cohesion, and improving load-bearing capacity. Similarly, cement stabilization offers improved compressive strength and durability, which qualifies it for a range of building uses.



|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

The compaction characteristics and bearing capacity of black cotton soil are affected by a number of additives, such as fly ash, brick dust, lime, and VA. Workability is improved by sodium hydroxide and sodium chloride. The best mix for better mechanical qualities is 3% lime + 20% VA. Lime and VA both greatly minimise soil plasticity. When combined, quarry dust and lime produce greater results than either admixture alone, and 30% percentage of coal bottom ash works best for stabilising black cotton soil.

Mechanical stabilization techniques focus on modifying the soil structure through methods such as compaction, preloading, and soil reinforcement. Compaction techniques aim to increase soil density, thereby reducing its susceptibility to volume changes and improving its bearing capacity. Preloading involves the application of external loads to accelerate consolidation and reduce settlement potential. Soil reinforcement techniques, such as the use of geosynthetics and soil nails, enhance the soil's tensile strength and stability, particularly in slope stabilization and earth retaining structures.

Biological stabilization methods utilize natural processes and materials to improve soil properties, including vegetation cover, microbial activity, and bio-cementation. Vegetation cover helps in reducing soil erosion, increasing soil moisture retention, and enhancing soil structure through root reinforcement. Microbial activity, including microbial-induced calcite precipitation (MICP), contributes to soil improvement by forming calcium carbonate cement, which enhances soil strength and reduces permeability. Bio-cementation techniques involve the injection of microbial solutions or urea to promote calcium carbonate precipitation, thereby stabilizing the soil matrix.

Despite the advancements in stabilization techniques, challenges persist in optimizing their effectiveness and sustainability, particularly concerning cost-effectiveness, environmental impact, and long-term performance. Furthermore, site-specific conditions and soil variability necessitate a tailored approach to stabilization, considering factors such as soil composition, climate, and intended use of the stabilized soil

II. LITERATURE REVIEW

1. Muzamil Majeed et al. (2021): This review paper explores the use of industrial waste, such as fly ash, blast furnace slag, and cement kiln dust, for soil stabilization in India. With a focus on recycling waste materials and enhancing soil stability, the paper discusses how these industrial by-products can be effectively employed to improve soil properties. Emphasizing sustainable practices, the study showcases the successful utilization of materials like fly ash and cement kiln dust in large-scale soil stabilization projects, demonstrating increased bearing capacity and reduced moisture content. The proposed approach holds promise for sustainable construction practices, offering enhanced mechanical properties and environmental benefits through the reuse of industrial waste.

2. Prof. Jitendra Sankre et al.(2023) : This research focuses on enhancing the engineering properties of black cotton soil through the addition of fly ash and brick dust for soil stabilization. The study conducted tests on various mixtures, revealing improved properties in the mixed soil. The maximum dry density (MDD) increased up to 1.77g/cc at 40% mixture content, declining at 50%. Optimum moisture content (OMC) was minimized (11%) at 50% mixture content. Furthermore, California Bearing Ratio (CBR) values significantly increased, reaching a maximum of 4.22 at 50% mixture content. The findings suggest that a 40% mixture is optimal for effective soil stabilization, offering potential applications in pavement, sub-grade embankment, and other civil engineering projects for black cotton soils.

3. N.Sandeep Kumar et al.(2020) : This report investigates the feasibility of stabilizing red soil using rice husk ash (RHA) and coconut coir fiber, presenting an eco-friendly approach to soil stabilization. Through various proportions (5% to 25%), the study evaluates swelling capacity, plasticity index, cohesion, and compaction characteristics of the expansive soil. Optimal results, including a maximum unconfined compressive strength of 142 kN/m², were achieved at a 15% mixture of RHA and 5% coconut coir fiber. The findings highlight the effectiveness of RHA and coconut coir fiber as stabilizing agents for red soil, enhancing its strength and suggesting potential applications in construction. The study emphasizes sustainable practices by reusing waste materials for soil improvement.

4. Prof. Rahul Sharma et al.(2021) : This research explores the sustainable use of waste materials, specifically Kota stone slurry and fly ash, for stabilizing black cotton soil. The physical and strength characteristics of black cotton soil are examined in relation to varying proportions and sizes of fly ash and Kota stone slurry mix. Results indicate a reduction in water holding capacity, decreased soil plasticity, and optimum water content, accompanied by an increase in peak dry density. The addition of Kota stone slurry and fly ash significantly enhances the unconfined compressive strength (UCS) of black cotton soil, attributed to the formation of cementation compounds. Optimal percentages for maximum UCS are identified, demonstrating the potential of this approach as an eco-friendly and cost-effective soil stabilization method in civil engineering applications. The findings also highlight the environmental benefits of repurposing waste materials and transforming waste dumps into usable areas.



|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

5. V. Preetha et al.(2019) : This study focuses on stabilizing black cotton soil, known for its low bearing capacity and high swelling characteristics, through the addition of natural fiber (sisal), lime, and silica fume. The experiment involves lab-scale footing analysis and PLAXIS software to evaluate the impact of these stabilizing agents on soil properties. The results demonstrate effective interlocking between sisal fiber and soil, leading to increased footing load and reduced settlement. Sisal fiber enhances tensile strength, while silica fume acts as a void-filling material, addressing soil swelling issues. Lime improves compressive strength, exhibiting a 20% to 30% increase. Reinforced loose subgrade shows a 2.5 times increase in load-carrying capacity. The study provides valuable insights into enhancing the stability and performance of black cotton soil for construction applications.

6. Samruddhi Tayde et al. (2021) : This study investigates the use of marble dust and rice husk ash (RHA) for stabilizing expansive soil, aiming to enhance its engineering properties in an environmentally friendly manner. The optimal RHA percentage for stabilization is determined to be 10%. Regardless of marble dust addition, the maximum dry density decreases, while the optimum moisture content increases. The most effective stabilization ratio is found to be 70:10:20 for soil, RHA, and marble dust, respectively. Test results indicate that marble dust improves soil strength, although its addition causes a decrease in maximum dry density. This economical and efficient soil stabilization method holds promise for addressing the challenges associated with expansive soil in construction projects.

7. T Raj Priyanka et al.(2018) : This study addresses the challenges posed by expansive soil in construction by stabilizing black cotton soil with marble dust, a byproduct of construction activities. Proctor tests reveal that as the percentage of marble dust increases (from 0% to 20%), there is a consistent rise in Maximum Dry Density (MDD) and a reduction in Optimum Moisture Content (OMC). The Unconfined Compressive Strength (UCS) of the soil samples exhibits a notable increase from 0.72 kPa to 4.1 kPa with the addition of marble dust. Immediate strength follows a similar trend, peaking at 15% marble dust content. Beyond this, a slight decline is observed. The study establishes an optimal percentage of marble dust to enhance the geotechnical properties of black cotton soil, presenting an eco-friendly solution to soil stabilization challenges in construction.

8. Kevin Maraka Ndiema et al. (2022) : This experimental study investigates the stabilization of Black Cotton Soil (BCS) in pavement subgrade construction using natural lime, volcanic ash (VA), and their combinations. The research reveals that adding 3% lime with 20% VA significantly enhances the mechanical properties of BCS, resulting in a remarkable 10.76-fold increase in California Bearing Ratio (CBR) values. The stabilised BCS satisfies the national road design handbook of Kenya's standards for Class S2 and above pavement subgrade materials. The mixture reduces swell potential by 88% and lowers the plasticity index by 29%. The study concludes that the 3% lime + 20% VA combination is an effective stabilizer for BCS, offering an alternative to traditional methods and contributing to costeffective road infrastructure construction.

9. Sandeep Singh et al.(2021) : This research addresses the challenge of construction and demolition (C&D) waste disposal by utilizing combinations of C&D waste, ground granulated blast furnace slag (GGBS), and polypropylene fiber (PPF) to enhance the geotechnical properties of Black Cotton soil. The study aims to reduce swelling and shrinkage in expansive soils, common issues leading to structural damage. Experimental findings indicate that optimal combinations of C&D waste, GGBS, and PPF effectively improve soil properties. The addition of these stabilizers increases the maximum dry density from 15kN/m³ to 17.86kN/m³ and decreases the optimum moisture content from 28.6% to 21.31%, demonstrating the potential for successful soil stabilization and sustainable waste management in construction projects.

10. J. Chetan Anand et al.(2020) : The increasing global population has led to a surge in construction activities, necessitating the use of expansive soils like Black Cotton Soil in India. However, the highly expansive nature of this soil, prone to swelling and shrinking based on moisture content, poses significant challenges to construction. To address this issue, an experimental study was conducted on Black Cotton Soil, introducing admixtures such as quarry dust and lime. The study revealed that combining quarry dust and lime produced more favorable results compared to using these admixtures separately. The addition of admixtures increased the soil's bearing capacity, demonstrating the effectiveness of quarry dust and lime in stabilizing expansive soils and mitigating construction challenges.

11. Mary Ann Q. Adajar et al.(2020) : This study explores the use of recycled gypsum and rice husk ash as additives in stabilizing expansive soils. Expansive soils, known for their risks to structural integrity, were treated with varying proportions of these additives. The results indicate that the addition of gypsum initially increased plasticity, while further addition of rice husk ash decreased it. Compaction characteristics improved, with the combination of 15% gypsum and 10% rice husk ash showing the most significant enhancements. The mixture also led to a substantial reduction in swelling, rendering the soil non-expansive. The study concludes that the combination of gypsum and rice husk ash is effective in improving the engineering properties of expansive soils, providing an economic and sustainable solution. Future research is recommended to explore shear strength and additional agricultural waste options.

12. Omkar Prakash Navagire et al.(2020) : Expansive soils pose engineering challenges due to low bearing capacity and significant shrink-swell characteristics. This study focuses on enhancing the strength properties of black cotton soil using Coal Bottom Ash (CBA) as a stabilizing agent. The investigation covers key parameters like



|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

Unconfined Compressive Strength (UCS), California Bearing Ratio (CBR), Maximum Dry Density, and Optimum Moisture Content. The addition of CBA, with its cementitious properties, improves soil strength and reduces shrinkage and swelling. Results indicate that up to 30% CBA addition, strength parameters increase, but a decline is observed beyond this threshold. The study concludes that an optimal 30% CBA content enhances geotechnical properties, offering insights for effective black cotton soil stabilization.

13. Ashish Mehta et al.(2020) : The paper addresses the challenges posed by expansive soils, covering approximately 51.8 million hectares of land in India, particularly focusing on Maharashtra. Expansive soils, notably black cotton soil, exhibit drastic changes in strength between dry and wet conditions. The study explores the stabilization of black cotton soil using fly ash from the Koradi thermal power plant. Various proportions of fly ash (0%, 10%, 20%, 30%, 40%, and 50%) were employed, revealing that fly ash reduces plasticity and enhances workability through colloidal reactions and grain size modification. California Bearing Ratio (CBR) tests under soaked and unsoaked conditions demonstrated the potential of fly ash as an additive to improve the engineering properties of expansive soils.

14. Prathap Pandit et al.(2020) : In response to the increasing demand for construction in India's expansive black cotton soil, engineers face challenges due to its low bearing capacity and strength. This study explores an eco-friendly alternative, Terrazyme, a bio-enzyme, for soil stabilization. The locally sourced expansive soil exhibited high plasticity, emphasizing the need for improvement. Terrazyme, although inadequate for consistency limits, proved effective in reducing compaction effort, enhancing workability, and increasing maximum dry density while decreasing optimum moisture content. The addition of Terrazyme at 0.5ml dosage notably increased the California Bearing Ratio (CBR) by 8.80%. While the initial cost is higher, the zero maintenance cost renders Terrazyme an economically viable solution. The study underscores the need for further validation through field experiments specific to the materials and conditions used in this research.

15. Hemant B. Vasaikar et al. (2015) : Designing foundations on expansive black cotton soil poses challenges as structures often develop cracks without warning. Found in states like M.P., Karnataka, Maharashtra, and Andhra Pradesh, black cotton soil properties vary based on constituents like water content, density, and shear strength. This project focuses on stabilizing the soil using lime, with experimental work incorporating 4% and 6% lime content. The study assesses properties such as liquid limit, plastic limit, optimum moisture content, maximum dry density, bulk density, C.B.R. test, grain size analysis, and swelling pressure. Results indicate substantial improvement in engineering properties with lime addition. Liquid limit decreases by 12.1% and 17.7%, and C.B.R. values increase six to eightfold, demonstrating lime's effectiveness in modifying black cotton soil properties.

16. J.C. Agunwamba et al.(2018) : This research explores the stabilization of black cotton soil (BCS) using sawdust ash, an economical material, and lime to enhance its suitability as a subgrade material. Sawdust ash was mixed with BCS in varying proportions, and the optimal combination of 16% sawdust ash and 4% lime demonstrated the best results. The stabilized soil exhibited reduced liquid limit, differential free swell, and plasticity index, along with increased CBR and specific gravity. Scanning electron microscope images revealed flocculation and agglomeration, while X-ray diffraction tests indicated pozzolanic reactions. This study suggests that the proposed method effectively stabilizes BCS, achieving strength with minimal lime content and utilizing sawdust as an environmentally friendly by-product. The resulting CBR value meets specified criteria for subgrade soils, offering a sustainable solution for expansive clay stabilization.

17. Ayushi D. Panchal et al.(2019) :This study investigates the improvement of black cotton soil, a poor-quality soil, through the addition of quarry dust in varying proportions (5%, 10%, 15%). The tests conducted include Atterberg's Limit, Compaction Test, California Bearing Ratio (CBR) Test, and Unconfined Compressive Strength (UCS) Test. The results indicate significant enhancements up to 10% quarry dust addition, where liquid limit, plastic limit, and plasticity index decrease, and maximum dry density increases. Beyond 10%, the effectiveness diminishes. The CBR value improves from 11.53% to 15.28% with 10% quarry dust, and UCS increases from 0.67 kg/cm² to 0.74 kg/cm². This suggests that up to 10% quarry dust addition is optimal for enhancing the engineering properties of black cotton soil.

18. Nadeesha H. Koralegedara et al.(2019) : This review explores the diverse and environmentally safe applications of flue gas desulfurization gypsum (FGDG), an industrial by-product from coal-fired power plants. FGDG, enriched with gypsum, has been increasingly produced with reduced hazardous elements. The study highlights its applications, including concrete, cement, asphalt, and water treatment, emphasizing recent advances. The potential reuse scenarios, research gaps, and necessary considerations are discussed. Novel applications, such as water treatment and soil stabilization, exhibit promising environmental benefits. Despite the advancements, there is a need for comprehensive analysis of FGDG composition and potential long-term effects, urging further research to maximize its beneficial reuse and minimize environmental impact.

19. Francisco José Moura et al.(2018) : This study assesses the potential of flue gas desulfurization (FGD) gypsum as a setting time retarder in Portland cement production, aiming to replace natural gypsum. The FGD gypsum,



|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

with predominant bassanite and hannebachite, demonstrated purity comparable to natural gypsum. Setting time delay of about 1 hour was observed with FGD gypsum, and the compressive strength was influenced by its content. Leaching tests classified FGD gypsum as non-hazardous and non-inert. The study suggests that FGD gypsum, with its retarding effect and positive impact on compressive strength, can be a suitable additive in Portland cement preparation, showcasing its potential as a sustainable alternative to natural gypsum in cement production.

III. MATERIALS AND TESTS

3.1 BLACK COTTON SOIL

Inorganic clays with medium to high compressibility, commonly referred to as black cotton soils, constitute a significant soil category in India. High shrinkage and swelling qualities define them. Approximately 20% of India is covered by black cotton soils.India's black cotton soil is created as a result of fissure volcanic rock weathering. Volcanic rocks that originated in the Deccan Plateau account for much of the black soil.

Also known as Regur Soil, it covers about 5.46 lakh sq km i.e about 16.6% of total land area of the country covering most of Deccan Plateau – Parts of Maharashtra, Karnataka, Madhya Pradesh, Gujarat, Andhra Pradesh and some parts of Tamil Nadu

It covers about 9.2% of total area of Karnataka .The north western region of Karnataka has black soil which supports oilseeds, cotton, peanuts etc.

Black cotton soil has the following geotechnical characteristics

Colour	Black
Specific Gravity	2.65
Liquid limit (%)	40-60
Plastic limit (%)	15-25
Shrinkage limit (%)	8-15
OMC (%)	20-30
MDD (g/cc)	1.4-1.6

Table – 1 : Characteristic features of BCS

3.1.1 Problems to use Black Cotton Soil

Black cotton soils exhibit distinct characteristics that pose challenges for construction and infrastructure stability. When these soils come into contact with water, they swell and become sticky, creating significant complications. During the dry season, they develop wide cracks due to their tendency to shrink when moisture levels decrease. These cracks can lead to various issues such as wide cracks in walls, heaving of floors, and uneven heaving of roads. Additionally, black cotton soils have a high moisture retention capacity, prolonging the duration of moisture presence in the soil. This moisture retention exacerbates their compressibility, making them highly susceptible to compression under load. Consequently, these soil properties present considerable challenges for construction projects, requiring effective stabilization techniques to mitigate the risks associated with their behavior.

• Expansive nature of black cotton soil

The expansive nature of black cotton soil, prone to swelling and shrinking, poses significant challenges for construction. Soil swelling can pressure foundations, causing cracks and structural damage, while soil shrinking leads to settlement and instability. These fluctuations jeopardize the integrity of buildings and infrastructure, distressing foundations, floors, and walls. To address these challenges, careful implementation of soil stabilization techniques is essential to mitigate risks and ensure the durability of constructed assets.



Fig -1 : Black Cotton Soil



|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

• Low Bearing Capacity Of BCS

Black cotton soil's low bearing capacity renders it unsuitable for supporting heavy structures or infrastructure. This limitation arises from its high compressibility and low shear strength, which result in insufficient support for substantial loads. Attempting to build on such soil without addressing its low bearing capacity can lead to settlement, foundation failure, and structural damage. To overcome this challenge, engineers employ various soil improvement techniques such as soil compaction, soil stabilization with additives like lime or cement, and the use of geotechnical solutions like piling or ground reinforcement. By enhancing the soil's load-bearing capacity through these methods, construction projects can proceed safely and effectively on black cotton soil, ensuring the stability and longevity of built structures.

• High Compressibility

The high compressibility of black cotton soil presents significant challenges for construction projects, as it can result in settlement issues. This property makes the soil prone to significant volume changes under load, leading to uneven settling of foundations and infrastructure. The potential for uneven settlement poses risks to the structural integrity of buildings and can result in costly repairs and safety concerns. To address this challenge, engineers employ various soil stabilization techniques, such as compaction and the use of stabilizing additives, to mitigate the compressibility of black cotton soil and ensure the stability and longevity of constructed structures.

3.2 FGD GYPSUM

An industrial by-product of the flue gas desulfurization process in coal-fired power stations is called flue gas desulfurization gypsum, or FGD gypsum.

It is recovered to reduce sulphur dioxide emissions from the exhaust gas system of such plants. FGD gypsum exists as single crystal particles and contains contaminants like Mg, K, Cl, F, B, Al, Fe, Si, and Se, originating from the limestone used in desulfurization and the coal burned. In many applications, including plasterboard, water treatment and cement set retarder, this product is pure enough to substitute real gypsum.

FGD gypsum is a synthetic gypsum produced during the removal of sulfur dioxide from flue gases, aiming to reduce air pollution by controlling emissions of sulfur dioxide, a major contributor to acid rain. Despite potential concerns about radioactive elements like radium and uranium present in low levels in some FGD gypsum samples, monitoring and managing radiation risks are essential, especially in large-scale applications.



Fig -2: FGD Gypsum

3.2.1 DEMERITS OF FGD GYPSUM

While Flue Gas Desulfurization (FGD) gypsum has several beneficial uses, there are potential challenges associated with its production and application. One concern is the presence of impurities and contaminants, such as heavy metals and trace elements, in FGD gypsum, which can vary depending on the specific FGD process and source.

These contaminants may limit the applications of FGD gypsum, particularly in certain industries or agricultural practices. Monitoring and managing the levels of impurities in FGD gypsum are essential to ensure its safe and effective utilization.

• Difficult Handling

Handling FGD gypsum, whether in single crystal form or as minute particles, presents challenges due to its size and structure. The small size and intricate nature of the particles can make them difficult to manage, leading to issues such



|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

as dust generation and potential handling hazards. Additionally, the tendency for fine particles to become airborne during handling poses health and safety risks to workers. Proper handling protocols, including the use of personal protective equipment and dust control measures, are essential to mitigate these challenges.

Particle Size Issues

The minute particle size of FGD gypsum raises concerns, particularly regarding potential health hazards from inhalation. Fine particles can easily become airborne during handling and pose respiratory risks to workers if inhaled. Inhalation of these particles may lead to respiratory irritation, lung inflammation, or other health complications. Therefore, proper ventilation, dust control measures, and the use of personal protective equipment are crucial to minimize exposure and mitigate the potential health hazards associated with handling FGD gypsum.

• Environmental Impact

Dumping of FGD gypsum without proper management poses significant environmental problems, including the potential for soil contamination. Improper disposal can lead to the leaching of contaminants from the gypsum into the surrounding soil, waterways, and ecosystems, harming flora, fauna, and human health. Additionally, FGD gypsum contains various chemical constituents, including heavy metals, which may pose risks to environmental and human health if released unchecked. Therefore, proper management and disposal practices, such as containment, recycling, or controlled application, are essential to mitigate these environmental impacts.

3.3 SCOPE OF USING FGD GYPSUM

The utilization of Flue Gas Desulfurization (FGD) gypsum in the stabilization of black cotton soil offers a promising and sustainable solution. FGD gypsum, a by-product of coal-fired power plants, can effectively amend soil to mitigate the expansive nature of black cotton soil. By enhancing soil stability, reducing shrink-swell behavior, and improving geotechnical properties, FGD gypsum contributes to environmental sustainability by repurposing industrial waste. This approach also provides a cost-effective soil improvement method, reducing the reliance on traditional stabilization techniques. The scope of using FGD gypsum extends to innovative practices that promote eco-friendly construction and agricultural development in regions affected by black cotton soil, addressing geotechnical challenges and fostering sustainable infrastructure solutions. Regulatory standards and guidelines are in place to manage the quality and application of FGD gypsum, ensuring its safe and effective use despite challenges such as quality variability, transportation logistics, market demand fluctuations, and potential environmental impacts if not properly managed.

IV. TESTS

4.1 Laboratory tests have been conducted to natural soil to determine following properties

- 1. Specific gravity
- 2. Atterberg Limits (Liquid limit, Plastic limit)
- 3. Plasticity Index
- 4. Maximum dry density
- 5. Optimum moisture content
- **4.2** Laboratory procedures to evaluate the effectiveness of FGD Gypsum as admixture at different concentrations 0f 10, 20, 30, & 40 %
- 1. Liquid Limit
- 2. Plasticity Index
- 3. Maximum Dry Density, MDD
- 4. Optimum Moisture Content
- 5. Unconfined Compressive Strength

V. CONCLUSION

In conclusion, the utilization of Flue Gas Desulfurization (FGD) gypsum in stabilizing black cotton soil presents a promising and sustainable solution to mitigate the challenges posed by this expansive soil type. By improving soil stability, reducing shrink-swell behavior, and enhancing geotechnical properties, FGD gypsum offers an environmentally friendly alternative to traditional stabilization methods. Despite challenges such as handling difficulties and environmental concerns, proper management practices can ensure the safe and effective use of FGD gypsum. Overall, the incorporation of FGD gypsum in soil stabilization practices holds significant potential for promoting eco-friendly construction and agricultural development while addressing geotechnical challenges in affected regions.



|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

VI. FURTHER WORK

Future research endeavours could focus on several key areas to explore the efficacy and feasibility of using FGD gypsum for stabilizing black cotton soil:

Optimization of Mix Proportions: Investigate the optimal mix proportions of FGD gypsum and black cotton soil to achieve desired engineering properties, including improved strength, reduced plasticity, and enhanced durability. This would involve conducting laboratory experiments and geotechnical tests to assess the influence of varying FGD gypsum contents on soil stabilization performance.

Effect of Curing Conditions: Evaluate the influence of curing conditions, such as curing time and moisture content, on the effectiveness of FGD gypsum stabilization. Long-term curing studies can provide insights into the durability and long-term performance of stabilized black cotton soil under different environmental conditions.

Mechanisms of Stabilization: Explore the mechanisms underlying the stabilization of black cotton soil with FGD gypsum, including chemical reactions, mineralogical changes, and microstructural modifications. This would involve advanced analytical techniques such as X-ray diffraction (XRD), scanning electron microscopy (SEM), and Fourier-transform infrared spectroscopy (FTIR) to characterize the interactions between FGD gypsum and soil particles.

Field-Scale Studies: Conduct field-scale trials to validate the laboratory findings and assess the practical applicability of FGD gypsum stabilization in real-world construction projects. Field monitoring and performance evaluation can provide valuable data on the effectiveness of FGD gypsum in mitigating soil-related issues and improving the stability of engineered structures built on black cotton soil.

Environmental Impact Assessment: Evaluate the environmental implications of using FGD gypsum for soil stabilization, including its effects on soil fertility, groundwater quality, and ecosystem health. Life cycle assessment (LCA) and environmental impact assessment (EIA) methodologies can help quantify the environmental benefits and trade-offs associated with FGD gypsum utilization compared to traditional stabilization methods.

By addressing these research gaps and challenges, further investigation into the application of FGD gypsum for stabilizing black cotton soil can contribute to sustainable soil management practices, enhance infrastructure resilience, and support eco-friendly solutions for geotechnical engineering projects.

REFERENCES

[1]. Akki, B. (2020). Stabilization of Black Cotton Soil using Terrazyme Enzyme. International Journal for Research in Applied Science and Engineering Technology, 8(8), 858–862. https://doi.org/10.22214/ijraset.2020.31037

[2]. Ambagade, S. (2021). Effect of Marble Dust & Rice Husk Ash to Stabilize Expansive Soil. International Journal for Research in Applied Science and Engineering Technology, 9(VI), 5102–5106. https://doi.org/10.22214/ijraset.2021.36035

[3]. Anand*, J. C., Jain, M., Kalyan, T. H., Rao, N. V. L., & Chamberlin, K. S. (2020). Stabilization of Black Cotton Soil by using Quarry Dust and Lime. International Journal of Innovative Technology and Exploring Engineering, 9(3), 3623–3626. https://doi.org/10.35940/ijitee.C8410.019320

[4]. Gniem. (2022). Stabilization of black cotton soil by Fly Ash Special Issue for National Conference On Recent Advances in Technology and Management for Integrated Growth 2013 (RATMIG 2013) ABSTRACT.

[5]. Ikeagwuani, C. C., Obeta, I. N., & Agunwamba, J. C. (2019). Stabilization of black cotton soil subgrade using sawdust ash and lime. Soils and Foundations, 59(1), 162–175. https://doi.org/10.1016/j.sandf.2018.10.004

[6]. Jitendra Sankre, P., Khawse, A., Kaushik, A., Husain, H., Hajare, R., & Nagle, S. (n.d.). Stabilization of Black Cotton Soil using Brick Dust and Fly Ash. www.ijirmps.org

[7]. Maiti, S., Jain, N., & Malik, J. (n.d.). A comprehensive review of flue gas desulphurized gypsum: Production, properties, and applications.

[8]. Maiti, S., Jain, N., Malik, J., Yichao, -Zhang, Ying, W., Jinghai, Z., Jiaxi, L., & Tong, L. (n.d.). SL NO TITLE AND AUTHOR NAME RESULTS REMARKS A comprehensive review of flue gas desulphurized gypsum: Production, properties, and applications. Basic characteristics and comprehensive utilization of FGD gypsum.

[9]. Nanda, P. (2021). Black Cotton Soil Stabilization by Using Fly Ash - Kota Stone Slurry Mix. International Journal for Research in Applied Science and Engineering Technology, 9(11), 1699–1703. https://doi.org/10.22214/ijraset.2021.39086

[10]. Nandan*, M. S., sai, K. V., Rakesh, P., Kumar, N. S., & Chamberlin, K. S. (2020). Stabilisation of Red Soil By using Coconut Coir Fibre and Rice Husk Ash. International Journal of Innovative Technology and Exploring Engineering, 9(3), 535–540. https://doi.org/10.35940/ijitee.B7633.019320

[11]. Navagire, P., Sharma, S. K., & Rambabu, D. (n.d.). Stabilization of black cotton soil with coal bottom ash. https://doi.org/10.1016/j.matpr.2021.10.447Get



|e-ISSN: 2319-8753, p-ISSN: 2347-6710| www.ijirset.com | Impact Factor: 8.423| A Monthly Peer Reviewed & Referred Journal |

|| Volume 13, Issue 2, February 2024 ||

| DOI:10.15680/IJIRSET.2024.1302055 |

[12]. Panchal, A. D., Student, B. E., Kotadiya, M. J., Patel, D. R., Naik, N. N., & Patel, K. P. (n.d.). Stabilization of Black Cotton Soil using Waste Material Quarry Dust. www.ijert.org Performance evaluation of black cotton soil with waste, fibers and minerals. (n.d.).

[13]. Priyanka, T. R. (2018). Stabilization of Black Cotton Soil with Marble Dust. International Journal for Research in Applied Science and Engineering Technology, 6(5), 2057–2060. https://doi.org/10.22214/ijraset.2018.5337

[14]. Ramesh, H. N., & Manjunatha, B. V. (2020). Justification of strength properties of microstructural changes in the black cotton soil stabilized with rice husk ash and carbide lime in the presence of sodium salts. SN Applied Sciences, 2(3). https://doi.org/10.1007/s42452-020-2226-1

[15]. Singh, S., & Vasaikar, H. B. (2015). Stabilization of Black Cotton Soil using Lime A COMPARATIVE STUDY OF SIMPLY SUPPORTED AND CONTINUOUS R.C.C. SLAB BRIDGES View project Stabilization of Black Cotton Soil using Lime. In Article in International Journal of Science and Research (Vol. 4). www.ijsr.net

[16]. Tan, J. F., & Adajar, M. A. Q. (2020). RECYCLED GYPSUM AND RICE HUSK ASH AS ADDITIVES IN THE STABILIZATION OF EXPANSIVE SOIL. International Journal of GEOMATE,17,197–202. https://doi.org/10.21660/2020.70.9201

[17]. V*, Preetha., V.M, G., M, A., R, R., & S, Nayannathara. (2019). Lab scale Footing Analysis on Stabilization of Black Cotton Soil. International Journal of Recent Technology and Engineering (IJRTE), 8(4), 1921–1926. https://doi.org/10.35940/ijrte.C5380.118419

[18]. Yichao, Z., Ying, W., Jinghai, Z., Jiaxi, L., & Tong, L. (2020). Basic characteristics and comprehensive utilization of FGD gypsum. IOP Conference Series: Earth and Environmental Science, 510(5). https://doi.org/10.1088/1755-1315/510/5/052002









INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN SCIENCE | ENGINEERING | TECHNOLOGY





www.ijirset.com