Influence of Sugarcane Bagasse And Ldpe Waste Plastic By Partial Replacement To The Black Cotton Soil At Subgrade

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Abstract- *The engineering characteristics of broad soils, particularly Black textiles Soil (BCS), present substantial challenges in construction for civil engineering as a result of their high plasticity, low shear strength, and substantial volume changes due to moisture fluctuations. Researchers have increasingly concentrated on environmentally conscious and cost-effective stabilisation techniques that utilise agricultural and industrial refuse in order to address these constraints and advance sustainable development. This review investigates the potential of ash from sugarcane bagasse (SBA) and low-density polyethylene, or LDPE, waste plastic as partial substitutes and additives to enhance the geotechnical features of BCS at the subgrade level. Sugarcane bagasse, a plentiful byproduct of the sugar sector, possesses pozzolanic properties that increase soil strength and decrease plasticity. Simultaneously, LDPE waste plastic, a major pollutant, when shredded and blended with soil, contributes to increased ductility and load-bearing capacity due to its tensile resistance. The combined application of SBA and LDPE provides a dual benefit—mitigating waste disposal problems while enhancing soil performance.This paper conducts a systematic review of previous research, experimental methods, and real-world applications that examine changes in features such as California Burden Ratio (CBR), unconstrained compressive strength (UCS), boundaries of Atterberg, and swelling behaviour. The review suggests that the optimal concentrations of LDPE plastic (0.5–2%) and the ash from bagasse (typically 5–10%) lead to substantial enhancements in subgrade stability.The findings support the integration of agro-industrial waste in pavement subgrade treatment, aligning with environmental sustainability and circular economy goals. Further research is suggested for long-term performance analysis under varying climatic and traffic conditions.*

Keywords- Black Cotton Soil, Sugarcane Bagasse Ash, LDPE Waste Plastic, Soil Stabilization, Subgrade Improvement, Sustainable Construction, Geotechnical Engineering.

I. INTRODUCTION

The significance of engineering in transportation in the advancement of a nation is multifaceted. The commercial development of any place or country is contingent upon the conveyance of all products, such as food, apparel, commercial goods, and medication, during every stage of the manufacturing and shipment process. Various structures, ranging from commonplace houses to skyscrapers, bridges to airports, and rural highways to motorways, are occupying land in every direction. The majority of the civil engineering buildings are situated on a variety of soil types. Soil is the unconsolidated material that is produced by the disintegration of minerals by a variety of weathering agents, such as water and oxygen[1]. Chemical changes that result from the benign combination of minerals beneath the rock formation with oxygen, liquid water, and external carbon dioxide are the cause of weathering and decomposition. As a result, the rock is undergoing the process of decomposition, resulting in the formation of grit, sediment, and clay. The transfer of soil parts by air, water, wind, and frost results in a variety of soil formations[2]. The growing process of soils is significantly influenced by temperature, rainfall, and discharge in various climatic regions[3].

India has been divided into five primary soil categories: 1. Alluvial Deposit 2. Black cotton Soil 3. Laterite Soil 4. Desert Soil 5. Marine Deposits

The adoption of ground enhancement techniques, such as soil stabilisation, is prompted by the encounter with land that contains loose soil for the purpose of constructing a structure. Stabilisation is achieved by augmenting the bending strength and overall load bearing ability of a soil[4]. Providing a robust working framework, stabilised soils serve as the foundation for every aspect of initiatives. The formation of lasting pozzolanic reactions can transform unstable soils following the application of stabilisation techniques[5].

Figure.1 Soil Stabilization

This implies that soils are not susceptible to erosion and have a significantly reduced permeability, which in turn reduces their potential for shrinkage and swelling. Furthermore, soils that were previously stabilised have also undergone some modification. In another word, the soil has undergone a physical transformation, which has resulted in a reduction in plasticity and an ease of compaction[6]. Achieving the utmost dry density is facilitated by the ease of compaction. The critical amount of water of soils are utilised to calculate the plasticity index, a critical geotechnical parameter[7]. Soils become more friable and practical when their plasticity is diminished.

1.1 Material Used

It is imperative to confront the obstacles presented by problematic soils in the context of sustainable construction practices and civil engineering[8]. Engineers are gravely concerned about the high expansion and contraction characteristics of black cotton the ground, which is widespread throughout India. Structures constructed on such broad dirt are susceptible to uneven shifting, fractures, and even failure of the structure. In order to address these challenges, soil stabilisation techniques have become an essential component of ground development strategies[9]. The integration of Waste Anything such as The substance and low- density polyethylene (LDPE) is a promising and ecologically conscious solution among the various methods that have been investigated.

1. Black Cotton Soil

In numerous regions of India, black cotton soil seems accessible. While developing a structure on the expansive ground, numerous complications may arise. This soil is characterised by a high degree of expansion and contraction, which renders it challenging to construct structures on it due to its extensive water absorption[10]. The expansive soil's ability to change shape may cause damage to a structure. As a result, it is imperative to enhance the mechanical properties of this soil by employing ground enhancement techniques. Consequently, soil fortification is one of the procedures that can be implemented to improve the properties of soil.

Figure.2 Black Cotton Soil

Black Cotton landscapes are soils that are exceedingly clayey and range in colour from greyish to dark grey[11]. They are found in a number of states across India. The black the cotton soils are formed out of rock or trap and contain a clay mineral called montmorillonite, which is responsible for the soil's abnormal expansion and contraction. Expansive soils generate numerous complications for civil engineering buildings. The characteristics during expansive soils are enhanced through the application of a variety of methods. In construction, soil levelling is a method that improves the engineering properties of soil, such as its strength and volume stability. When mechanical stabilisation fails to improve the soil's strength properties, a chemical mix technique is implemented to achieve the desired strength[12]. Chemical stabilisation is the most frequently implemented method for enhancing physical and mechanical properties of problematic soils, such as expansive soil and porous soil.

2. Bagasse

Fibrous residue is produced through the extraction of sugarcane liquid, which is known as bagasse. India produces nearly eighty trillion pounds (MMT) of bagasse. The dispersal of bags is a substantial concern. This bagasse as a is hazardous and may be reused or thrown of in the water's body, which leads to contamination. The rate of residual lignocellulose sugarcane bags (RSB) generation and the development of the Indian sugar industry are mutually reinforcing[13]. It is estimated that 600 operational sugar refineries in India produce more than 75–90 million tonnes of moist RSB annually. Consequently, the sugar industries and scientific organisations worldwide must prioritise the efficient utilisation of residual bagasse. It is crucial to employ it in a manner that is environmentally friendly, as it has a tendency to cause damage[14].

Figure.3 Bagasse

3. Low Density Polyethylene (LDPE)

India's plastic production is steadily increasing. Recycling plastics is an alternative method of managing plastic refuse. The packaging industry is the primary application for LDPE. LDPE is the primary material used to construct milk containers. The majority of domestic waste is generated by dairy product containers, including milk pouches, yoghurt pouches, and buttermilk pouches[15]. Additionally, each tea kiosk generates approximately 40 to 50 butter containers. This plastic is recyclable; however, it may generate complications if it fails to reach the recycling facility. Additionally, the utilisation of plastic items has increased substantially, which may result in numerous environmental concerns. Therefore, plastic is also employed in this context to facilitate the stabilisation process. The utilisation of plastic materials for soil stabilisation can be regarded as an environmentally beneficial approach[16].

Figure.4 Crushed Low Density Polyethylene

A synergistic stabilisation effect can be obtained by combining black cotton soil with LDPE and bagasse. Bagasse enhances the soil's elastic properties and internal friction, while LDPE improves its water resistance and durability. These materials collectively reduce the expansive behaviour of the soil, enhance compaction characteristics, and enhance the overall durability and performance of the stabilised soil[17]. This approach is especially advantageous in rural road building, foundation care, and embankment projects that are low-cost and environmentally friendly, as conventional stabilisers may be prohibitively expensive or environmentally detrimental.

The use of these two waste materials for stabilization not only addresses the technical challenges of construction on expansive soils but also provides a responsible method for managing agricultural and plastic waste[18]. Implementing this approach on a larger scale could contribute significantly to waste minimization and sustainable infrastructure development.

Environmental and Economic Benefits

The environmental implications of this strategy are noteworthy. By diverting bagasse and LDPE from waste streams, this technique helps mitigate pollution and reduce landfill pressure. It promotes resource efficiency and reduces dependence on virgin chemical stabilisers, thereby supporting the objectives of sustainable development. Especially in agricultural and resource-constrained regions, the utilisation of locally available refuse materials can reduce construction costs from an economic perspective[19].

In summary, the utilisation of bagasse and LDPE to stabilise black cotton soil is a progressive method in the field of geotechnical engineering. It transforms environmental liabilities into construction assets, promotes sustainable practices, and addresses the dual challenge of soil instability and waste management[20]. As India continues to expand its infrastructure, embracing such eco-friendly innovations will be critical for ensuring resilient, cost-effective, and environmentally sound development.

II. LITERATURE REVIEW

Especially for subgrade applications, soil stabilisation is essential for improving the durability and effectiveness of feeble or expansive soils, such as black cotton soil. Although conventional methods are effective, they are growing more expensive and environmentally damaging due to the use of cement, gypsum, and chemical additives. Rajshekhar G Rathod has et al. (2017) conducted an experiment on coloured or black cotton soil to investigate the effects of chemical stabilisation using Terrassa. The study revealed that the Maximum Dry Displacement (MDD) and the California Bearing Ratio, or CBR, of the treated soil were substantially enhanced by chemical stabilisers, thereby illustrating the efficacy of chemical fertilisers in poor enhancement[21]. In the same vein, Rajshekhar G Ra Thad et al. (2018) examined the impact of pulverised sand on the black cotton soil. The concept that the combination of natural materials and additives can enhance feeble soil profiles is further substantiated by the improvement of soil penetration and resistance as a result of an inclusion of 5%, 10%, alongside 15% pulverised sand.

Adding to this views, Kiran R. G along with colleagues (2013) demonstrated significant enhancements in CBR and Free compressed strength (UCS) when they combined bagasse ash with concrete and lime, particularly at 8% mix ratios. However, excess lime led to a reduction in density. The quest for sustainable stabilizers was also evident in Leonardo Behak et al. (2015), where Rice Husk Ash (RHA) combined with cement improved UCS values, but beyond a 6% mix, the performance declined. As a supplement to conventional chemical remedies, these findings collectively underscore the urgent need for cost-effective and environmentally benign stabilisers[22].

The utilisation of agricultural waste, such as bagasse ash, rice straw ash, and similar by-products, presents a promising solution for the improvement of soil properties and the resolution of waste management issues[23]. Bagasse ash, a byproduct of the sugarcane industry, has been demonstrated to be an excellent soil amendment. Kiran R. G et al (2013) found that the UCS and CBR values of black cotton soil were significantly increased when stabilised with 4–12% ash of bagasse together with lime or cement. Notably, the 8% mix ratio was particularly effective in improving strength without compromising soil density. In a related study, Leonardo Behak et al. (2015) also emphasized the efficacy of agricultural waste, where the incorporation of RHA with cement improved soil strength indices, although performance declined at higher ash proportions[24].

Adding to the literature, Deepa et al. (2012) reported the application of coir pith ash in expansive soils, resulting in improved compaction and reduced plasticity index. Similarly, Kaniraj and Havanagi (2001) utilized fly ash with black cotton soil and observed remarkable improvements in strength and durability under cyclic loading. These studies consistently highlight that agro-waste materials can replace a portion of soil or traditional stabilizers in subgrade preparation, contributing to sustainable construction practices[25].

The ever-growing issue of plastic waste disposal has led researchers to investigate the reuse of LDPE and other plastic wastes as potential stabilizers in soil. The interaction between the soil particles is potentially enhanced by plastics, which are hydrophobic and non-biodegradable, thereby increasing their resistance to moisture and load-bearing capacity[26]. A thorough investigation was conducted by S. Peddaiah and others (2018) regarding the reinforcement of silty sand with beverage bottle strips. Their findings indicated substantial enhancements in MDD, tensile strength, and value of CBR at a desirable strip dimensions of 15 mm × 15 mm and a 0.4% plastic content. This is consistent with the findings of Kumar et al. (2014), who found that LDPE fibres in clay soils improved ductility and strength, particularly at modest concentrations.

Further studies such as those by Ramesh and Chaitra (2017) showed that shredded plastic added to expansive soils improved strength and reduced volumetric changes during wet-dry cycles. Muntohar and Hantoro (2000) also reported increased load resistance in clayey soils blended with polypropylene waste. These research outcomes affirm the dual benefit of waste plastic inclusion — solving environmental challenges while improving subgrade performance[27]. The flexibility and tensile strength offered by LDPE help bind soil particles, reduce plasticity, and enhance structural stability.

An emerging trend in geotechnical research is the synergistic use of both agricultural and plastic waste in stabilizing soils[28]. This approach leverages the pozzolanic nature of agricultural waste and the tensile characteristics of plastic to create a balanced, high-performance subgrade material. While individual studies like those by Kiran R. G et al. (2013) and S. Peddaiah et al. (2018) focus separately on bagasse ash and plastic waste, the integration of these materials could potentially harness their complementary properties. In practice, the bagasse ash contributes to cementitious bonding and moisture absorption, while LDPE provides flexibility and resistance to deformation under stress[29].

Researchers such as Rakesh Kumar et al. (2016) experimented with soil–plastic–fly ash mixtures and observed significant strength improvements, suggesting that hybrid stabilization methods are viable. Additionally, investigations by Jain and Singh (2017) indicated that combining shredded plastic with pozzolanic materials improved workability and mechanical performance under varying moisture conditions. Though specific studies on sugarcane bagasse + LDPE in combination are limited, the current literature strongly supports their individual effectiveness and provides a rationale for their joint application in subgrade stabilization[30].

Quantitative analysis through standard geotechnical tests is essential to validate the performance of stabilized soil mixtures[31]. In order to evaluate performance, the majority of studies employ parameters such as Maximum Dry Dimension (MDD), Optimum Moisture Composition (OMC), Unconfined compressed strength (UCS), and the state of California Bearing Ratio (CBR). MDD grew from 1.17 g/cm³ on 1.91 g/cm³ in the study undertaken by Rajshekhar G He et al. (2017), and CBR values multiplied as a result of the introduction of chemical stabilisers. These findings plainly demonstrate enhanced compaction and resistance to loads.

In the same vein, Ss. Peddaiah et al. 2018 showed a substantial increase in strength at shear and CBR at the optimal material strip ratios, which serves as confirmation of the efficacy of plastic incorporation[32]. Kiran R. G et al. (2013) observed that the use of bagasse ash in conjunction with lime or cement resulted in an increase in UCS and CBR, especially in the mid-range blend percentages. In parallel, Leonardo Behak et al. (2015) validated improvements using resilient modulus (Mr) tests, further reinforcing the reliability of these enhancements in actual pavement applications.

Further support comes from studies like that of Jain and Singh (2017), where repeated load triaxial tests confirmed long-term strength and deformation control in plastic-stabilized soil. These studies highlight the critical role of test-based validation in establishing the practical feasibility of waste-based stabilizers in road construction.

The addition of waste materials such as bagasse from sugarcane and LDPE plastic to subgrade products not only improves durability but also represents an environmentally sound approach to resource optimisation and waste management. Bagasse ash, a byproduct of sugar refineries, is readily accessible in agricultural regions, whereas LDPE waste is a significant urban pollutant[33]. Utilizing these in soil stabilization can mitigate environmental concerns related to landfill overuse and soil contamination.

According to S. Peddaiah et al. (2018), plastic-reinforced soil systems offer a dual benefit: reduced plastic waste accumulation and cost-effective road base stabilization. In a similar vein, Lorenzo Behak et al. (2015) and Kiran R. G et al. (2013) underscored the fact that the utilisation of agro-waste reduces the need for costly additives such as cement and calcium. Additionally, these environmentally favourable alternatives contribute to the reduction of carbon footprints, which is consistent with the objectives of sustainable infrastructure development[34].

Rathod et al. (2018) noted that replacing part of the black cotton soil with crushed waste not only reduced material cost but also improved longevity and maintenance cycles of pavements. Consequently, the economic and ecological advantages serve as a compelling incentive for engineers and policymakers to promote the implementation of waste-based soil stabilization [35].

The existing literature review emphasises that both the ash from sugar cane bagasse and LDPE garbage plastic have substantial potential to enhance the geotechnical attributes about black cotton soil to basement applications. Studies consistently show that individual and combined applications of these waste materials enhance critical parameters like MDD, CBR, UCS, and shear strength[36]. While agricultural waste contributes pozzolanic reactions that improve bonding and strength, LDPE imparts flexibility and durability, particularly under dynamic loads. Furthermore, these methods are cost-effective, environmentally sustainable, and technologically feasible for developing regions.

However, future research should focus on optimizing blend ratios, studying long-term performance under field conditions, and developing guidelines for practical implementation. A partial substitution about black cotton soil at the ashes of bagasse and LDPE waste presents an intriguing possibility in road poor engineering as the demand for environmentally conscious building methods increases[37].

III. RESEARCH METHODOLOGY

The investigation methodology for the present review paper will employ an organised technique to assess the current body of literature and compile pertinent studies regarding the utilisation of bagasse made from sugarcane and low- density polyethylene, or LDPE, discarded plastic as partial substitutes to earn black cotton soil within the subgrade stage for road construction.

The first step will involve a comprehensive literature search using databases like Google Scholar, ScienceDirect, and Scopus to identify peer-reviewed articles, conference papers, technical reports, and case studies. Keywords such as “sugarcane bagasse,” “LDPE waste plastic,” “black cotton soil,” “subgrade,” and “road construction” will be used to filter relevant documents. This search will focus on studies published in the last two decades to ensure that the findings are up-to-date and encompass the latest advancements in the field[38].

Once the relevant articles are identified, the papers will be analyzed for their methodology, experimental setups, findings, and conclusions. The primary objective will be to comprehend the influence of LDPE waste plastic and sugarcane bagasse on the geotechnical traits of black cotton soil, consisting of its resilience, compaction characteristics, and strength[39]. Factors like optimal replacement percentages, soil stabilization methods, and the environmental benefits of using agricultural and plastic waste will be explored.

A comparative analysis of different research outcomes will be conducted, identifying trends and highlighting variations in results based on geographical, experimental, and methodological differences. The potential advantages and drawbacks of utilising these components in subgrade soil usage will be comprehensively examined, with a focus on key themes such as economic viability, sustainability, and material durability[40].

In order to optimise the utilisation of refuse materials for soil stabilisation in road construction projects, the paper will conclude by summarising the current body of knowledge, identifying research voids, and proposing future research directions[41].

IV. RESULTS AND DISCUSSION

A reliable and cost-effective methodology in geotechnical engineering has emerged for the stabilisation of Black Clover Soil (BCS) using manufacturing and farm refuse materials. Among the various materials investigated, sugarcane bagasse ash (SBA) and low-density polyethylene (LDPE) waste plastic have attracted particular attention due to their beneficial properties and environmental advantages. The geotechnical behaviour of soil can be considerably enhanced, particularly in terms of endurance, flexibility and expansion potential, by the partial replacement of SBA and LDPE in BCS stabilisation, as demonstrated by a comprehensive review of the existing literature[42].

Black Cotton Soil is widely recognized for its problematic behavior, especially in the presence of moisture. Its high the material clay content results in excessive swelling and contraction characteristics. These fluctuations can severely damage building foundations, roads, and other infrastructure built over BCS. Hence, improving its engineering properties is essential for sustainable construction practices. Research studies have highlighted the potential of SBA and LDPE to address these challenges effectively[43].

Sugar Cane Ash (SBA) represents a byproduct that is produced as a result of the combustion of plant refuse in sugar refineries. SBA is renowned for its cementitious properties when combined with drinking water and reactive soil minerals, and it is abundant in alumina, silica, and other pozzolanic compounds[44]. SBA endures pozzolanic interactions with calcium hydroxide, a mineral that is either present in the soil or introduced externally when used as a stabilising agent in BCS. These reactions result in the growth of the secondary calcium silicate hydrate, or C and calcium aluminium nourish (C-A-H) compounds, which bond the soil particles jointly, thereby increasing the strength and decreasing plasticity[45].

Numerous studies confirm the effectiveness of SBA in improving the **unconfined compressive strength (UCS)** of BCS. For instance, Singh et al. (2020) conducted a laboratory investigation where BCS samples were treated with various percentages of SBA. In comparison to unadulterated soil, they discovered that a 7% exchange of SBA resulted in an additional 30% in UCS. The greater particle bonding that results from the emergence of cementitious compounds is responsible for this improvement[46]. Moreover, the optimal percentage of SBA addition generally falls within the range of 5% to 10%. Beyond this range, the strength gain tends to plateau or even decline, likely due to the excessive ash content disrupting the matrix formation rather than contributing to it.

SBA is instrumental in the reduction of the plasticity score of BCS, in addition to augmenting strength. This decrease suggests a decrease in the disparity between the liquid and plastic limits, which results in enhanced compaction characteristics and improved workability. Reduced plasticity is advantageous for construction, as it lowers the chances of shrinkage cracks and swelling under wet conditions[47]. Improved compaction ensures that the soil achieves a higher dry density, which is beneficial for load-bearing capacity.

On the other hand, **Low-Density Polyethylene (LDPE)** waste plastic—an abundant and non-biodegradable material primarily generated from packaging and household waste—has also shown promise in enhancing the mechanical behavior of BCS. When shredded LDPE plastic is mixed into the soil, it acts as a reinforcement, improving ductility, reducing brittleness, and increasing the soil's ability to withstand deformation without cracking[48]. This behavior is attributed to the tensile strength of LDPE, which provides an anchoring mechanism, preventing the soil particles from dislocating under applied loads.

Studies investigating the effect of LDPE on BCS report that small quantities of shredded plastic (typically ranging from 0.5% to 2% by weight) can lead to noticeable improvements in critical performance parameters. The California Bearing Ratio, better known as the CBR, is often employed to evaluate the suitability of the substrate for subgrade construction, and it is one of the most important indications of this improvement[49]. Research indicates that the incorporation of 1% LDPE can result in a 50% increase in

CBR, contingent upon the compaction effort and the soil's basal properties.

LDPE's contribution to reducing the **swelling potential** of BCS is particularly important. Swelling, caused by moisture ingress in expansive clay soils, is one of the main factors behind pavement and foundation failures in black cotton regions. LDPE's water-resistant nature acts as a physical barrier to moisture movement, thereby mitigating the moisture sensitivity of BCS. This helps maintain soil volume stability and improves its performance over seasonal changes.

The synergistic use of **SBA and LDPE in combination** has shown even more promising results. While SBA improves the chemical and strength characteristics through pozzolanic activity, LDPE contributes to the physical integrity and tensile behavior of the soil matrix[50]. A study by Kumar et al. (2021) reported that the optimum blend of 8% SBA and 1% LDPE resulted in a remarkable 40% increase in UCS and a 50% improvement in CBR, compared to untreated BCS. This dual approach not only enhances the geotechnical properties but also offers an innovative way to manage agricultural and plastic waste, promoting sustainability in construction.

Importantly, the improved performance resulting from SBA and LDPE additions is not limited to strength alone. There are also improvements in **durability**, **resistance to moisture variations**, and **reduced permeability**, all of which are vital for long-term infrastructure stability[51]. The ductile behavior imparted by LDPE helps the stabilized soil absorb minor ground movements without cracking, while the reduced plasticity and porosity from SBA addition lower the risk of water ingress.

However, it is crucial to acknowledge that the performance of SBA and LDPE-stabilized BCS can vary based on several factors. Soil mineralogy, local climatic conditions, the specific properties of the waste materials used, and the magnitude of traffic loading can influence outcomes significantly[52]. For example, the reactivity of SBA can differ depending on the burning temperature and method used in sugar mills, which affects its pozzolanic quality. Similarly, the size, thickness, and shape of LDPE shreds can alter the reinforcement mechanism within the soil. Therefore, while laboratory results provide a strong basis for the potential of these materials, **field validation** through real-world pilot projects is essential to confirm their long-term viability.

Furthermore, some challenges remain, such as the uniform mixing of LDPE shreds in the soil matrix and the potential leaching of microplastics into the environment. Proper protocols for waste collection, processing, and integration must be developed to ensure safety, consistency, and environmental protection[53]. Field trials should also consider external factors such as freeze-thaw cycles, water table fluctuations, and heavy vehicular movement to comprehensively assess the durability of the stabilized soil.

In conclusion, the combination of sugarcane bagasse ash and LDPE waste plastic presents a highly effective and environmentally sustainable method for stabilizing Black Cotton Soil[54]. This approach not only improves strength and durability but also provides a meaningful solution to two pressing waste management problems—agricultural ash and plastic waste. With proper quality control, standardization, and field trials, this method has the potential to transform infrastructure development in regions with expansive soils, making it more resilient, economical, and environmentally friendly.

V. CONCLUSION

An original and sustainable approach for addressing the challenges caused by expansive dirt in subgrade situations is provided by the integration of ash from sugar cane bagasse (SBA) and the use of LDPE garbage plastic as partial substitutes in Black textiles Soil (BCS) stabilisation. The engineering properties of BCS are substantially enhanced, including diminished plasticity, improved loose strength under compression, California Bearing Ratio, and mitigated swelling behaviour, as demonstrated by the review of numerous studies. The optimum use of SBA (5–10%) and LDPE, or plastic (0.5–2%) is recommended.

These findings support the use of agro-industrial waste as a viable solution for soil stabilization, aligning with environmental sustainability goals by reducing waste disposal issues and contributing to circular economy practices. However, it is essential to conduct long-term performance studies under varying environmental and traffic conditions to fully assess the practicality and durability of these materials in the field.

Investigating the potential of combining such compounds with other eco-friendly stabilisers, as well as examining the effects of varying concentrations of SBA and LDPE plastic in a variety of soil types, should be the primary focus of future research. Furthermore, it is imperative to conduct a comprehensive investigation into the consequences of climate fluctuations on the long-term effectiveness of stabilised soils in order to guarantee their dependability in practical applications.

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