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Effect of Fiber Reinforcement on the Tensile Strength and Ductility of Fly Ash Based Composites

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ABSTRACT

In India, the majority of power production (73%) is generated from thermal sources, with coal-based production contributing 90% of the total installed power capacity. This reliance on coal for power production results in significant amounts of fly ash, a byproduct, which is often disposed of in on-site impoundments behind engineered earth dams. As the country continues to rely on coal for power generation, the management of fly ash becomes a growing concern. One potential solution for utilizing fly ash is to use it as a construction material for applications such as embankments and fills. In this study, the properties of fly ash and galvanized iron (GI) reinforcement were investigated, along with the effect of reinforcement on the stress-strain behavior of fly ash. A series of laboratory tests were conducted on fly ash using uniaxial compression tests. The tests were performed on fly ash samples with varying dry densities and optimum moisture content (OMC), determined through standard proctor tests. Additional tests were conducted using modified proctor tests to obtain different dry densities and OMC values. The stress-strain behavior of the fly ash samples was analyzed by varying the number and location of GI reinforcement. The study found that the inclusion of GI reinforcement increased the peak stress and axial strain at failure. Additionally, as the number of GI reinforcements increased, the effect of reinforcement on the fly ash decreased. The study also observed that reducing the moisture content percentage resulted in increased strength of the fly ash. Overall, the study concluded that the inclusion of reinforcement in fly ash layers can significantly increase their strength and stiffness. As a result, comparable strength can be achieved even with a reduced thickness of the fly ash layer. This research highlights the potential for utilizing fly ash as a construction material and the positive impact of GI reinforcement on its mechanical properties. Implementing such practices could provide sustainable solutions for fly ash management in India's power generation sector.

1. INTRODUCTION

Composite materials are characterized by their composition of multiple chemically distinct components on a macro scale, with a clear interface separating them. These materials exhibit bulk performance that significantly differs from that of their individual constituents. Whether used in buildings, bridges, pavements, or other applications, composites must possess strength and the ability to withstand external forces. These forces can arise from applied loads, and composites incorporate a load-carrying material called reinforcement. The reinforcement provides strength, stiffness, and support to bear the applied load. One common component used in composite materials is fly ash, which is a residue produced by coal-based thermal power plants. Fly ash consists of fine particles that are carried away with the chimney gases during combustion. The quantity of fly ash generated by a single plant can range from less than one ton per day to several tons per minute. Fly ash is typically divided into two categories based on its source and chemical/mineralogical properties. Low-calcium fly ash is produced from the combustion of anthracite or bituminous coal, while high-calcium fly ash is generated from the burning of lignite or sub-bituminous coal. Both types of fly ash contain a substantial amount of amorphous glass.

In summary, composite materials play a vital role in various applications due to their unique combination of different components. Fly ash, a byproduct of coal-based thermal power plants, can be utilized as a component in composites. Understanding the properties and characteristics of fly ash, along with its classification based on source and chemical composition, contributes to the development of composite materials with improved strength and performance.

2. UTILIZATION OF FLY ASH

Fly ash, derived from bituminous and sub-bituminous coals, finds various applications in civil engineering. One common use is as an admixture to Portland cement, where it improves the workability, strength, and reduces the heat of hydration of concrete. Fly ash can also be utilized in soil stabilization, either in combination with lime or by itself, to enhance the bearing capacity of road base and sub-bases. Additionally, fly ash can be mixed with water, Portland cement, and sand to create flow able fills that exhibit liquid-like behavior during placement and solidify thereafter. Other reported applications of fly ash include grouts, fast-track concrete pavements, and its use as structural fills and backfills in construction projects. Overall, fly ash offers versatility and contributes to the improvement of various construction materials and techniques in civil engineering.

3. LITERATURE REVIEW

➢ It is also used in tooth paste, kitchens ,floor tiles , bowling, frames auto bodies and boat hulls, cellular concrete, geopolymers, roofing tiles, roofing granule, deck, fireside mantle, cinder slab, doors, window frames. And also use for house hold materials ,benches, chairs, toys. It is also used like paintings and under coatings. It is used like filler wood , plastic things. **[1]** Fly ash used in concrete and it also used as a alternate material for cement and sand

✓ It is used in Embankments , structural fills
✓ It is also used like grout and fill.
✓ It can be used for stabilization of waste.
✓ Fly ash used as a alternate material for clay
✓ Mine reclamation
✓ Used for the soft soils in stabilization
✓ It also used Roads for the sub grade.
✓ Used as alternative material for aggregates
✓ Used in fill in concrete.
✓ It is also used in agricultural .like fertilizer
✓ movable uses on rivers
✓ It is also used for ice control in roads.

- The properties like grain size, water-density relation, shear strength, compressibility and permeability above mention physical and engineering properties are very useful determine the behaviour of the embankment. The tests are used for the soil in the lab we can also use for the fly ash. Due to the chemical properties of fly ash physical properties also change and class of the leach ate formed beside the fly ash. The physical and chemical and engineering properties of fly ash will be different in different power plants. Leach ate characterize of fly ash also will change according to the power plants **[3].**
- By and large if the rate of fly ash more than 30 in cementations materials then it will called like high volume fly ash solid(HVFAC). High volume fly ash solid(HVFAC) lesser expense and more strong than ordinary solid and it will offer imperviousness to sulfate strike. Numerous flourishing field requisition has been done. Satisfactory early qualities and set times are gotten by with high extend dampness reduction to accomplish a low concrete degree. Admissible bond substitution rates are confined by state transportation division stipulation **[4].**
- According to the ASTM C618-93 fly ash divided into 3 categories. These are named as class C, class F and class N. if u burn bituminous coal class C fly ash will produce. If u burn sub-bituminous coal class F fly ash will produce. In class N volcanic ashes generally fall down **[5].**

✓ *Class N*: Raw or calcined natural pozzolanic such as some diatomaceous earths, opaline, chart and shale, stuffs, volcanic ashes and pumice are included in this category.

✓ *Class F*: Fly ash normally produced from burning anthracite or bituminous coal falls in this category. This class of fly ash exhibits pozzolanic property but rarely, self hardening propriety.

✓ *Class C*: Fly ash normally produced from lignite or sub-bituminous coal is the only material included in this category**[5].**

- In many soils fly ash is using for improving the strength of the soils and improve the properties. Fly ash may be use to steady bases and sub grades, we can stabilize the back fill due to the the lateral earth pressure will decrease due to this process stability of soil will increase. Generally depth of fill is 14 to 45 centimetres. The reason behind use of fly ash in the soils for the stabilization application because due to fly ash compressive and shearing properties **[6]**

The compressive strength of fly ash treat soils is dependent relative on:

✓ *Soil properties*

✓ *hold-up time*

✓ *water content*

✓ *amount* of fly ash

- Fly ash can be used like admixture to improve the properties of concrete. In cement up to 60 percentages it contains lime. If hydration process going on less amount of lime will be free. When fly ash is present with free lime, it will react property of concrete will increase **[7].**

Fly Ash Properties affecting use in PPC **[7]**

✓ *Fineness: The fineness of fly fiery remains is essential in light of the fact that it influences the rate of pozzolanic movement and the workability of the cement.*

✓ *Specific gravity: although particular gravity does not specifically influence solid quality, it has esteem in recognizing changes in other fly fiery debris attributes.*

- ✓ *Chemical composition: The touchy alumina silicate and calcium alumina silicate segments of fly* ash debris are routinely spoken to in their oxide terminologies, for example, silicon dioxide, aluminum oxide and calcium oxide.

- ➢ The geo synthetic will be roll on core have potency enough to evade fall down or other damages as of normal utilize. Every roll will be wrapping by a plastic casing to give protection to the geo synthetic from damage while transportation and handling, we have to attach the durable label which clearly mention its properties we have attach this label outside of the roll. The label must have the name of the manufacture and its style number and its weight and its dimensions. Roll categorization identical to the designed place of the roll as exposed on the structure drawing and it must be approved by the engineer. We have protect against damage of geo textile materials while transporting the geo textile materials we have take care damage due to wrapping and label and material itself. We have take care of the geo textile while storing many days in the same place for this we have take care of the material and label. we also protect against sun light and acids and temperatures and animal and human destruction **[9].**

- ➢ If used Steepened slopes u can increase the land use minimize the land develop cost. So it is desire now using steep slope. if use tensile reinforcement in the steepened slopes the strength of slope will increase . Steepened slopes reinforced with geo textile materials will increase land usage considerably even as long as a natural appearance. The main advantage of the reinforced fly ash slope decreases the erosion of soil slope due to water run-off and waves assault. Slope face erosion might generate rills and gully, and consequence in exterior sloughing failure (Berg.1994). Erosion manages and re-vegetation procedures have to, consequently essential division of all reinforced soil slope system design. The sort of erosion manage facing alternative chosen depends resting on the completed slope face angle **[11].**

- ➢ Slopes are generally positioned beside of the highway and it is also serving as margin for the buildings in maximum areas of country. Generally the flat areas wish for the construction of buildings, highways. Those areas should be dig out of the available land, frequently departure major grade change at the limits of the excavation. The financial possibility of construct a exacting highway alignment the improvement of a pack of land might be resolute through the faculty to produce sufficient flat, , or access requirements. Reinforced steepened slopes provide commercial earnings to attain more capable grade change than is likely with unreinforced slopes **[12].**

- ➢ For the reinforced slopes we have provide minimum factory of safety. In general from the experiments we found minimum factor of safety is 1.5. But sometimes the factor of safety changes for the different sites. So for the factor of safety calculation we have take recommendation from the geo technical engineer who is well known about that site and loading conditions, method construction **[12].**

- ➢ The simplified method developed by Bishop describes the circular slip analysis for determining the factor of safety against slope failure. The factor of safety is the ratio between the resisting forces and the causing moments, which are evaluated using the two-part wedge method of slices. In this method, the forces acting on each slice are determined by considering the weight of the soil and any surface loadings. The resisting moments increase as the soil shear resistance along the failure surface increases. This shear resistance is directly related to the mobilized soil shearing resistance. One advantage of Bishop's method is its ease of use for analysis. The values can be easily modified to incorporate the resisting moments provided by any reinforcement layers intersecting the failure surface. This flexibility allows for the inclusion of reinforcement measures recommended by the FHWA guidelines for reinforced slopes. Overall, Bishop's method provides a practical approach to assessing the factor of safety against slope failure by considering the interaction between resisting forces and causing moments. It aligns with the recommendations set forth in the FHWA guidelines for reinforced slopes. **[13].**

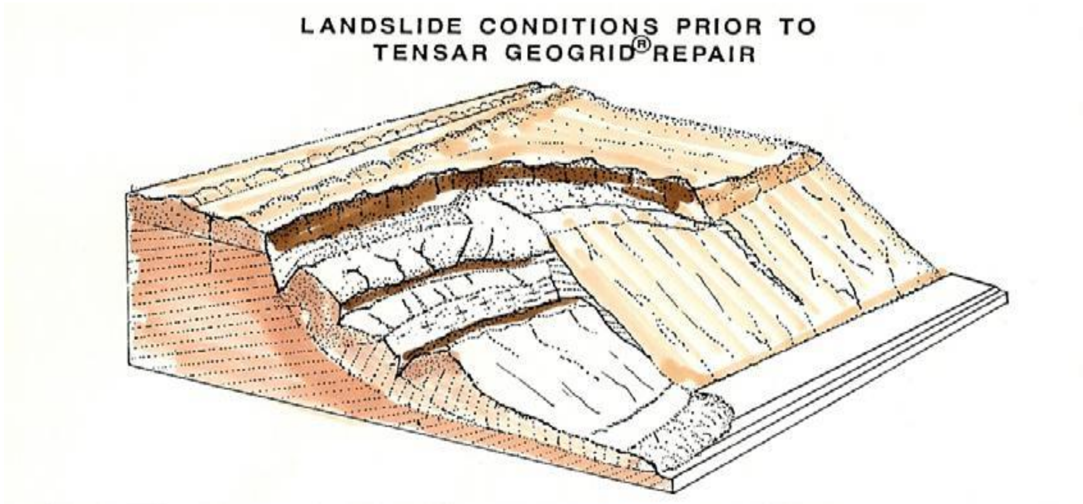
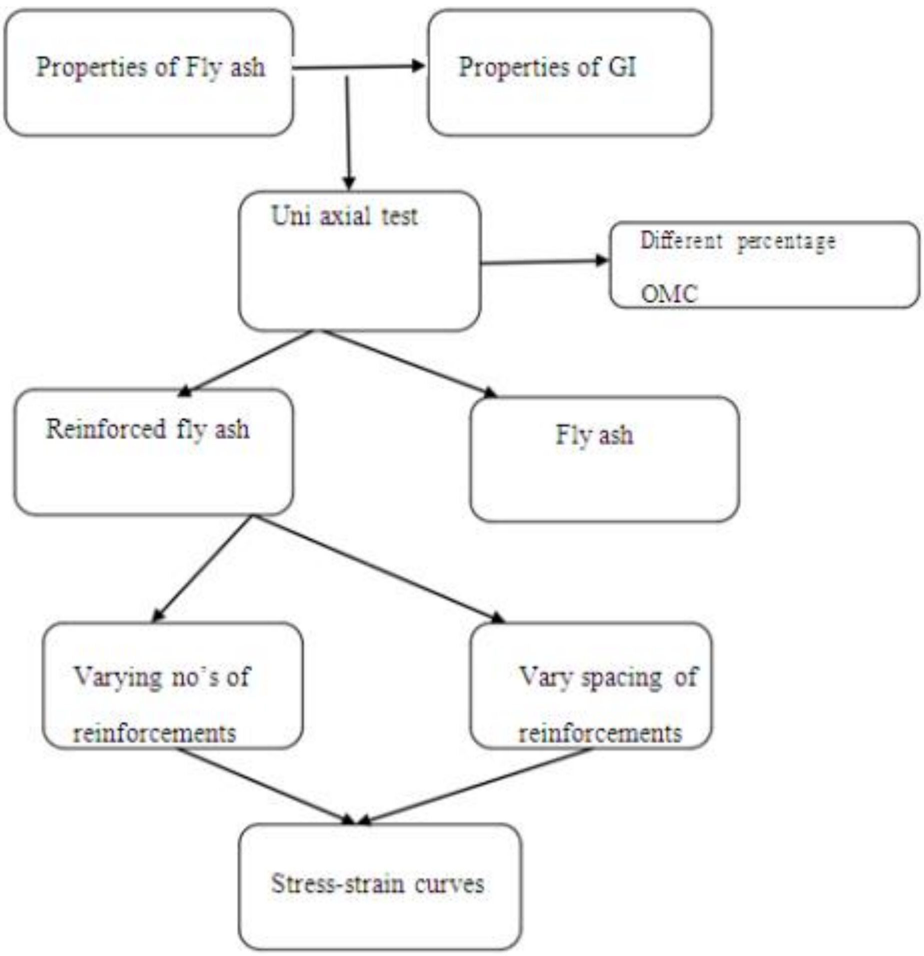


Figure: slope repaired with tenser geo grid

4. METHODOLOGY



5. CONCLUSIONS

The study involved conducting a series of uni-axial compression tests on multiple samples, both in reinforced and unreinforced conditions. Based on the experimental results, the following conclusions can be drawn:

- ✓ The inclusion of GI reinforcement significantly enhances the peak strength of the samples, as well as the axial strain at failure. Moreover, it reduces the loss of strength observed after the peak point.
- ✓ Comparing the samples prepared at standard proctor density and modified density, it is observed that the increase in peak stress is higher for the modified density samples. A similar trend is also noticed for the peak strain.
- ✓ The percent deviation of optimum moisture content (OMC) is found to vary significantly across all the tested cases. This suggests that the moisture content has a notable influence on the behavior and properties of the fly ash samples.

In summary, the experimental findings indicate that the inclusion of GI reinforcement has a positive impact on the strength and performance of the samples. The modified density samples exhibit greater improvements in peak stress compared to the standard proctor density samples. Additionally, the OMC variations have implications for the behavior of the fly ash samples.

FUTURE SCOPE:

The future scope of this project encompasses several potential areas of exploration and development, including:

- ✓ Replacement of fly ash: Further research can investigate the feasibility and performance of substituting fly ash with other materials such as red mud, pond ash, or different combinations of alternative materials. This would help assess the viability of using these substitutes in fly ash-based composites and explore their impact on the tensile strength and ductility.
- ✓ Alternative reinforcement materials: The study can be extended to evaluate the effects of using reinforcement materials other than GI reinforcement. Different types of reinforcements can be investigated to understand their influence on the strength characteristics of fly ash-based composites. This would provide insights into the suitability of alternative reinforcement options and their potential advantages or limitations.
- ✓ Confinement studies: The present study can be expanded to include confinement studies, where the samples are subjected to simulated field conditions. By incorporating confining factors and studying the behavior under realistic conditions, a more comprehensive understanding of the tensile strength and ductility of fly ash-based composites can be obtained. This would bridge the gap between laboratory findings and real-world scenarios.

In summary, the future scope of the project involves exploring the replacement of fly ash with alternative materials, investigating alternative reinforcement options, and conducting confinement studies to enhance the applicability and understanding of fly ash-based composites in practical settings.

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