STRENGTHENING OF SUBGRADE CLAYEY SOIL IN ROAD CONSTRUCTION USING FLY ASH AND COIR GEOTEXTILE

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Abstract. The best handicap for a carried-out community of road structures in growing international locations like India is the restricted monetary assets accessible to construct roads the use of traditional methods. By the usage of nearby substances inclusive of neighbourhood grounds for the constructions of the lower layers of the pavements (in precise the subgrade), the development expenses can be extensively reduced. 20% of the land in India is clayey and is expansive in nature. These lands are observed to be steeply-priced to construct and to maintain roads. The use of coir fibre substances in the discipline of civil engineering has led to new methods for stabilisation of soils in particular. A coir fibre (CF) is an herbal cloth that is broadly handy in Coastal India. A certain find out about was carried out in this paper about enhancing the stability, energy and sturdiness of soil clay mixed up with fly ash and coir fibre mat. The sample of the soil used was from the excessive clay region in Andhra Pradesh. The stabilisation was performed with classification C fly ash and grade H2M9 coir mat. The plasticity of clay fly ash mixes is decreased as fly ash content material is increased. Adding fly ash consequently lessens increasing soils and will increase their working-ability via a colloidal response and adjustments in grain size. The supplementation of fly ash led to full-size increase in soil CBR. The consequences exhibit large enhancement in compaction and CBR of composite containing clay, fly ash and coir mat. The most CBR value acquired was 44% for coir mat positioned at mixture of h/4th and h/2th depth from pinnacle in standard fly ash - clay mix.

Key words: Coir Fibre, California bearing ratio, clay soil.

1. Introduction

Soil stabilisation is an extend in soil balance through the usage of managed compaction or by means of including enough admixtures or stabilisers. Compaction and drainage are the easiest stabilisation processes. The 2nd technique is to enhance particle dimension by means of including binders to the vulnerable soil and can be in addition improved. Soil stabilisation can be carried out with a number of methods. All these techniques are included via two sizeable categories, particularly mechanical and chemical stabilisation. In mechanical stabilisation of the soil stabilisation, the bodily nature of native soil particles can be affected by using precipitated vibration or compaction or with the aid of different bodily features, such as obstacles and nailing. The stabilisation of soil via chemical stabilisation frequently relies upon chemical reactions to acquire the preferred impact between stabilisers (cementery material) and soils (pozzolanic materials). The usually used stabilisers are lime, cement, bitumen, ash or fly ash, etc. gasoline pulverised.
1.1 Objectives of the study

- To investigate the properties of virgin Andhra Pradesh clay soil
- To improve the strength of sub grade clayey soil using fly ash and coir geotextile.
- To check the application of fly ash and geotextile in high volume traffic.
- To study the strength properties of soil treated with fly ash and coir geotextile and obtain best percentage mix for better results.

2. Literature Review

Hakari and Puranik (2012): This article examines the effect of Dandeli flyash processing on the index, compaction and strength possessions of the Hubballi-Dharwad BC soil to improve its geotechnical properties. It has been experimental that the geotechnical houses of the Hubballi-Dharwad BC soil are significantly increased with the use of Dandeli fly ash as a stabilizer. The coefficients of plasticity consisting of the liquid limit, the plastic limit and the shrinkage limit show positive changes in their values. With fly ash, the shrinkage limit will increase while the fluid and plastic limit will decrease. The higher dry-density will increase with the equivalent reduction in ultra-moisture content. The California load rate and the unlimited piezoelectricity of these lands indicate an explosion in their value with the addition of fly ash.

Ashish Mehta et al. (2013): The paper presents their dwellings in various parts of the vast territory of Maharashtra in India. Black cotton is stabilised with fly ash in this observation (obtained from the Coradi thermal power plant). With different proportions of fly ash, the expanded soil is stabilised. Null, 10, 21, 30, 40% and 50%. There is no plasticity in the fly ash. The fly ash blends' plasticity index decreases as the material becomes less fly ash content. Thus, flight ash increases the expansion of soilless plastic and its functionality by modifying the colloid reaction and the length of the grains. CBR values for clays mixed with fly ash were tested under wet and wet conditions, and the results were discovered there; impact evaluation determined that fly ash across miles has great potential for use as a stabilizer to improve home engineering for large soils.

Mukherjeel and Vesmawala (2013): Fly ash is profitable until it is put to proper use. It has now emerged not as a simple aid but also as an environmental saviour. Although fly ash is an old practice in
roads and construction, there is still hesitation in using fly ash as pavement and building fabric for various purposes. Fly ash is a finely divided residue that is transmitted by gaseous gases to the boiler by the combustion of pulverised or pulverised coal. Lime fly ash drug will increase the California Tolerance Ratio (CBR); only when eighty-five percent of fly ash is added, the price of C.B.R is expanded.

Baruah et al. (2013): A similar investigation was conducted to explore the behaviour of soil reinforced with coconut mat. Coconut mats are used to intensification the bearing capacity of the lower grade. Laboratory and simulation studies of CBR studies were accomplished on soil samples with and without coir mats and their various locations in the mould. The use of the coir mat accelerated the CBR cost of the subfloor, thus greatly reducing the thickness of the pavement. From the CBR control results, it was experimental that the CBR value of the floor increased by 63% in the junk condition and 190% in the wet condition, and the coconut mat shifted to a position of 1 cm above the upper floor. The design aspect found that the coating thickness could be reduced by about 75% if the coir mat was placed over the subfloor.

3. Methodology

- Collection of materials i.e., Andhra Pradesh clay, coir mat and fly ash.
- Testing of virgin Andhra Pradesh clayey soil.
- Determination of optimum percentage of the fly ash.
- Determination of optimum placement depth of the coir mat in clay fly ash mix
- Comparison of the results
- Conclusion

4. Properties of Soil

4.1 Soil:

In Andhra Pradesh, the clayey soil used for mastering has become accrued. Clayey soils are medium to excessive inorganic clays and form a vital soil group in India. They are characterized with the aid of immoderate retrenchment and swelling. This clay-filled soil happens specially in the vital and western elements and covers around 20% of India. The terrestrial soils (BC) had been a twin-carriage to engineers' corporation due to its excessive swelling and shrinkage traits. The clay soil is hard whilst it is dry, however while it's far humid it loses its control completely. In clay soil, wealthy part of montmorillonite is determined from mineralogical analysis. Excessive expansion is by means of excessive percentage of montmorillonite. The outcomes of this property break up the soil without givein a heed in the soil. In addition, these cracks might also sometimes attain severe limits. So, constructing that centred on this soil may additionally go through extreme injury with the alternate of atmospheric conditions.

Figure 2. Soil sample.
4.2 Fly Ash

Fly ash is a combustion residue that includes the satisfactory debris to shift up with the waft fuel Ash, which doesn’t jab up, is now known as backside ash. Fly ash normally refers to ash produced during coal combustion in a business context. Fly ash is usually captured with the aid of electrostatic precipitation or diverse particulates filtration gear earlier than the flue gases attain the coal-fired power plants chimneys, and is collectively taken into consideration coal ash with the backside ash removed from the lower back of the furnace.

![Figure 3. Class F and class C fly ash.](image)

| PARAMETER                          | Limits                  |
|------------------------------------|-------------------------|
| Specific gravity                   | 1.90-2.550              |
| Plasticity                         | Non plastic             |
| Maximum dry density (g/cc)         | 0.90-1.60               |
| Optimum moisture content (%)       | 18 to 38                |
| Cohesion (KN/m²)                   | Negligible              |
| Angle of internal friction (degrees)| 30 to 40               |
| Coefficient of consolidation, Cv (cm²/sec) | 1.75x10⁻⁵ to 2.01x10⁻³ |
| Compression index, Cc               | 0.05 to 0.4             |
| Permeability                        | 8x10⁻⁶ to 7x10⁻⁴       |
| Coefficient of uniformity, Cu      | 3.1 to 10.7             |

4.3 Coir Geotextile

Geotextile is one of the best geosynthetics. The construction of pavements and recesses on clean soils are a known feature of geotextiles. They are fibrous and non fibrous. The fabric generally has at least one of the four distinct purposes, e.g., Separation, reinforcement, filtration and drainage. The desire to use polymer geosynthetic materials could be natural geotextiles made of cocoa fibre, jute fibres, sisal etc. Coir web is prepared, cheap, accessible and biodegradable materials. coir web. Coir geotextile can find its duties to perform in geotechnical or engineering applications in a number of preconditions. Coir geotextiles can be used as a surface or interlayer for the first to protect the floor against ruin and the second to perform separation, refurbishment, filtration and drainage points.
Table 2. Chemical Properties of Coir Fiber

| PROPERTY     | %      |
|--------------|--------|
| Lignin       | 45.84  |
| Cellulose    | 43.44  |
| Water soluble| 5.25   |
| Pectin       | 3.00   |
| Ash          | 2.22   |
| Hemicellulose| 0.25   |

Table 3. Physical properties of Coir Fiber.

| Property         | Value                  |
|------------------|------------------------|
| Width            | 222 µ                  |
| Length           | 15-280 mm              |
| Diameter         | 0.1 – 1.5 mm           |
| Young’s modulus  | 4.5 GN/m²              |
| Tenacity         | 10 g/tex               |
| Breaking elongation| 30 %                  |
| Density          | 1.15 - 1.4 g/cc        |
| Porosity         | 40 %                   |
| Swelling in water| 5 %                    |
| Rigidity modulus | 1.89 dynes/cm²         |

5. Results and Discussion

5.1 Hydrometer Test

Graph showing the variation of size of particles in a soil sample (IS 2720 Part 4) The graph suggests that the curve is less than 0.002 mm in particles, which is why the pattern can be labeled as clay.

5.2 Atterberg’s Limits

The results obtained from Atterberg’s limits test on virgin Andhra Pradesh clayey soil
Figure 4. Gradation Curve.

Table 4. Atterberg’s Limits on Virgin Andhra Pradesh Clayey Soil. (IS 2720 Part 5)

| Index Properties     | Value (%) |
|-----------------------|-----------|
| Liquid limit          | 56        |
| Plastic Limit         | 24        |
| Plasticity Index      | 32        |

Table 5. Variation of Plasticity Characteristics with Various % of Fly Ash.

| Fly Ash (%) | LL (0-day Curing) (%) | PL (7 days Curing) (%) | PI (7 days Curing) (%) |
|-------------|-----------------------|------------------------|------------------------|
| 0           | 56                    | 24                     | 32                     |
| 10          | 49.5                  | 20.37                  | 29.13                  |
| 15          | 44.5                  | 18.26                  | 26.24                  |
| 20          | 42                    | 16.19                  | 25.81                  |
| 30          | 36.5                  | 14.09                  | 22.41                  |
| 40          | 34.5                  | 12.75                  | 21.75                  |
5.3 Free Swell Index

![Graph Showing Variation of LL for various % of Fly Ash.](image1)

![Graph Showing Variation of PL for various % of Fly Ash.](image2)

**Figure 5.** Variation of LL for various % of fly ash.

**Figure 6.** Graph Showing Variation of PL for various % of Fly Ash.

**Table 6.** Free Swell Index. (IS2720 Part 40)

| Material          | Free Swell Index (%) |
|-------------------|----------------------|
| Clay              | 130                  |
| Clay + fly ash    | 50                   |

5.4 Standard Compaction Test

The dry density of fabric increases by means of as much as 22% with the widening of the water content material fabric and the dry density decreases steadily with similar widening of the water content material. The driest density and the most reliable moisture content material received have been 1.614 g/cc and 22.54 percent respectively. (IS 2720 Part 7)
5.5 California Bearing Ratio Test:

The evaluation of unsoaked CBR for 0% and 15% of fly ash. With the addition of FA, there used to be an extend in CBR about twice as that of initial. The low CBR of the virgin clay-soil is because of its inherent low robustness due to the dominance of the clay fraction (instead of the combination of clay-fly ash. Increase the CBR of the mixture by way of adding fly ash to the clay soil. This is because, frictional resistance from FA contributed further to the harmony of the soil. Further enlargement of the FA percentage, notwithstanding the reality that the decreasing clay-surface content material cause a reduction in CBR.

| % Fly ash | CBR VALUE (%) |
|-----------|---------------|
| 0         | 4.96, 6.39    |
| 15        | 12.58, 15     |

Table 7. Unsoaked CBR value.
Table 8. Variation of Unsoaked CBR Value for Various Positions of Coir Mat (IS 2720 Part16).

| Position of coir geotextile in clay +fly ash (15%) mix | CBR VALUE (%) |
|-------------------------------------------------------|----------------|
|                                                       | 2.5 mm Penetration | 5 mm Penetration |
| 3h/4 from top                                           | 21.84            | 25.38            |
| h/2 from top                                            | 28.8             | 28.91            |
| h/4 from top                                            | 39               | 40               |
| h/2 & 3h/4 from top                                     | 32               | 33.31            |
| h/2 & h/4 from top                                      | 43               | 44               |

Figure 9. Bar chart showing Variations in Unsoaked CBR value with differently positioned Geo Textile.

Where, M1 - Clay
M2 - Clay + Fly ash
M3 - Clay + Fly ash + Geotextile placed 3h/4 from top
M4 - Clay + Fly ash + Geotextile placed at h/2 from top
M5 - Clay + Fly ash + Geotextile placed at h/4 from top.
M6 - Clay + Fly ash + Geotextile placed at both 3h/4 & h/2 from top.
M7 - Clay + Fly ash + Geotextile placed at both h/4 & h/2 from top.

5.6 Unconfined Compression Test

The impact of accumulation of fly ash to the clayey soil samples on their UCS values alongside with the version of UCS which make bigger in the curing length. It suggests that the UCS of the clayey soil samples will increase with the addition of FA, suggesting an enhancement taken in the potentiality feature of the clayey soil + fly ash mixes. It is found that, there is an extend in the values of UCS for smaller curing duration of 7 days. It is considered that the power of soil will increase on accumulation of small proportion of 15% of fly ash.
Further extend in fly ash proportion suggests minimize in the strength. This is probably due to the disturbance of soil skeleton and consequent deduction in cohesion. The strength of soil enhanced significantly with curing time which is due to the pozzolanic reactivity of the free lime content material of the fly ash. The compressive potential of clay will increase with making fly ash content up to 15%, and then the value decreases with similarly accumulation of fly ash. (IS 2720 Part 10).
6. CONCLUSION

The building value can be significantly reduced by using deciding on domestically reachable substances for the development of the down layers of the pavement in particular the sub-grade. But the regionally accessible soil may be broadly speaking expansive soil making the stabilization of expansive or clayey soil is very necessary in pavement construction. From the literature research it is clear the fly ash and coir geotextile are advantageous in stabilizing the sub-grade soil. From the assessments carried out on virgin Andhra Pradesh soil it is clear that the soil is surprisingly plastic and impermeable. Therefore, the clayey soils ought to be stabilized to enhance its properties.

Class C fly ash and coir geotextile is used as a stabiliser for enhancing the geotechnical traits of virgin Andhra Pradesh clayey soils. Addition of category C fly ash considerably improves the index properties, compaction and potential traits of clayey soils, the consequences of fly ash remedy fluctuate relying upon the extent of fly ash, that is blended with the clayey soil samples.

The liquid restrict and plastic restriction of the soils reduce with the addition of fly ash which shows a proper exchange as the soil + fly ash combine can attain shear power at an early stage than the virgin soil with the alternate in the water content. The relative minimize in the plasticity index of the soils is every other beneficial exchange due to the fact it will increase the workability of these soils.

Adding of fly ash brings in an improvement in the compaction parameters of the clayey soils, through growing the driest density of soils with reduce in the equivalent values of best moisture content. The unconfined compressive solidity of these soils will increase upon the adding of fly ash. The style of enhancement in the unconfined compressive energy is to be greater stated with the curing of the soil + fly ash mix. All the tests are conducted according to IS 2720.

The following conclusions can be drawn from the study conducted:

- Optimum potential is received by changing 15% of clayey pattern with fly ash.
- Unconfined compressive strength of clay will boom through up to 15 % with the aid of fly ash, and in the end by an increase in fly ash volume Plasticity index decreases.
- The swelling trait was lowered by 60% of original.
- The unsoaked CBR value brought to be about 7 instances increased than that of virgin clay in way of placing coir mat at h/4 & h/2 from highpoint and the soaked CBR acquired is to be 5 instances higher than virgin clay.
- Since CBR acquired is above 30 %, the stabilized clayey soil can be used as sub grade for excessive extent traffic.

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