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Subgrade Soil Stabilization Using Chicken Feather Fiber

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***Abstract*— Sub grade soil is an integral part of the road pavement structure as it provides the support to the pavement from beneath. Poor sub grade soil conditions can result in inadequate pavement support and reduce pavement life. Thus soils properties may be improved through the addition of chemical or additives which is know as stabilization. These additives range from waste products to manufactured materials and include lime, Class C fly ash, Portland cement, cement kiln dust, fibers etc. These additives can be used with a variety of soils to help improve their native engineering properties. The effectiveness of these additives depends on the soil treated and the amount of additive used. Design of the various pavement layers is very much dependent on the strength of the sub grade soil over which they are going to be laid. The sub grade strength is mostly expressed in terms of California Bearing Ratio (CBR). For an engineer, it's important to understand the change of sub grade strength. This project is an attempt to understand the strength of sub grade in terms of CBR values. Treatment with chicken feather fiber (CFF) was found to be an option for improvement of soil properties, based on the testing conducted by varing percent(0.1%, 0.25% and 0.5%)of feathers . It was found that with the addition of stabilizers i.e. CFF, the C.B.R. increased upto a certain limit because CFF served as a reinforcement in soil but after that the C.B.R. decreased, due to replacement of soil by CFF.**

***Index Terms*— CFF, stabilization, strength assessment , Subgrade soil.**

I. Introduction

Subgrade layer is the lowest layer in the pavement structure underlying the base course or surface course, depending upon the type of pavement. Generally, subgrade consists of various locally available soil materials that sometimes might be soft and/or wet that cannot have enough strength/stiffness to support pavement loading. A sound knowledge of performance of the subgrade soil under prevailing in-situ condition is necessary prior to the construction of the pavement . The better the strength/stiffness quality of the materials the better would be the long-term performance of the pavement and thinner pavement layers. Hence, the design of pavement should be focused on the efficient, most economical and effective use of existing subgrade materials to optimize their performance. Most economical and efficient method in current practice to improve the properties of soil is stabilization which involves the use of stabilizing agents (binder materials) in weak soils to improve its engineering properties such as compressibility, strength, permeability and durability. Recent investigation on stabilization is using waste materials like fibers, a part of waste valorization

The storage or leaving of various products, which are obtained as waste products, creates a lot of problems in the means of environmental pollution. Putting waste products in good use prevents the pollution of nature by decreasing the usage of limited natural sources and decreases the problems that might occur when the waste products are stored for throwing. In parallel with the increase in the world's population, the pollution in food sector has also increased. Chicken feather is an example of waste products in food sector and this kind of waste products, which contain fiber,can be described as natural products. In the last decades, there has been an increasing interest in using natural materials (e.g., chicken quill (CQ) and carpet waste) as reinforcements in fine-grained soils. This occurs not only for environmental reasons but also for their properties and sustainability (Amieva et al. 2014).

Presently, huge amount of chicken feather disposed by different poultry industry as a solid waste arise solid-agricultural dispose issues. Chicken feather has more than 90 % protein called keratin. Keratin fibers is amino acid which able to crosslink with polymer matrix by forming disulfide or hydrogen bonds which enhance the fiber/matrix interaction to become stiff, strong, and lightweight properties. Furthermore, the advantages of chicken feather fiber are strictly bio-compatible, non-abrasive, low density, and warmth retention which promotes in reinforcement of polymer composites (Meyers et al.,2008). Present study focuses on strength properties of CFF stabilized soil.

A. Objectives and scopes

- The objectives of the project formed are the following:
- To determine the effectiveness of CFF as a sub grade soil stabilizer
- To determine the optimum content of CFF in soil to achieve the desirable sub grade characteristics
- Utilisation of sustainable materials like chicken feather fiber for soil stabilization

B. Need

Stabilization can increase

- the shear strength of a soil
- improving the load bearing capacity of sub grade soil to support pavements
- control of shrink swell properties
- to reduce compressibility
- increase in durability
- soil waterproofing
- reduction of pavement thickness

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- elimination of excavation, exporting unsuitable material and importing new materials

II. EXPERIMENTAL INVESTIGATIONS

Methodologies and experiments conducted on native soil and CFF added soils were included. various test conducted includes sieve analysis, liquid limit and plastic limit, California bearing ratio test (for native soil and also for 0.1%,0.25% and 0.5% of CFF added soil)

A). Materials and methodology used in study

a) Soil

Soil sample from Jyothi Engineering College was collected at required quantity. Conducted laboratory tests to study various properties on soil such as

1. Sieve analysis test
2. Liquid limit
3. Plastic limit
4. California Bearing Ratio test (CBR)

b). Chicken Feather Fiber

Chicken feathers are deliberated as a waste product of the poultry industry. Feathers are greatly ordered, hierarchical branched structures, that is standing among the most complex of keratin structures establish in vertebrates. Chicken feather consist of mainly three parts barbs ,quill(calamus) and rachis(Elda Montes-Zarazúa et al.), as shown in fig 1.

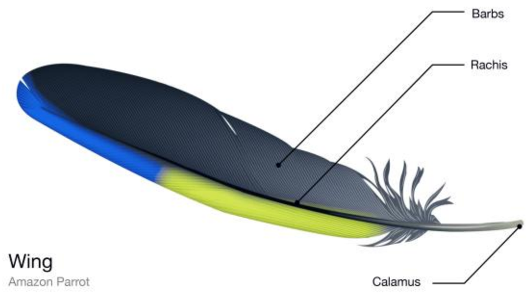

Fig 1: Parts of feather

c). Washing and cleaning of CFF

Clean the chicken feathers using water and hair drying shampoo. After completely washing the feathers two to four times in a bucket it was then kept in an open atmosphere for 24 hours. Results obtained showed complete dry, clean and less sticky appearance. Thus the cost effective method was produced but it has lesser effectiveness as compared to other chemical processes. And the dried feather were cut in to 6cm in length.

d). CFF -soil Matrix

Fix water content at 10%. The different values adopted in the present study for the percentage of fiber reinforcement are 0.01, 0.25, and 0.5. When fiber reinforcement was used, the adopted content of fibers was first mixed into the air-dried soil in small increments by hand shown in fig 2, making sure that all the fibers were mixed thoroughly, so that a fairly homogenous mixture is obtained, and then the required water was added.

Fig 2: Mixing of CFF and soil

e).Test conducted on CFF-soil matrix

CBR test were conducted on CFF matrix with 0.1%, 0.25% and 0.5% of CFF.

III. OBSERVATIONS

Effective size of particle	0.72mm
Uniformity Co-efficient	5.3
Co-efficient of curvature	1.4
Percentage of silt and clay	15.2%
Liquid limit (WL)	104%
The Plastic limit (WP)	25.92%
Plasticity index (IP)	78.08%
CBR value for virgin soil	43.9
CBR value for 0.1% CFF added soil	44.30
CBR value for 0.25% CFF added soil	45.94
CBR value for 0.5% CFF added soil	29.5

IV. CONCLUSIONS

The following conclusions were drawn from above study:

- From the above obtained result of soil properties, the soil is characterised in to inorganic clay of high plasticity .
- The above results says that by addition of 0.1% of CFF there is a increase in bearing capacity at a rate of 0.1% and at 0.25% CFF bearing capacity increases at a rate of 4.6% and at 0.5% the bearing capacity again decreases by an amount of 32.08%.
- It was found that the C.B.R. increased upto a certain limit because CFF served as a reinforcement in soil but after that the C.B.R. decreased, due to replacement of soil by CFF.
- Optimum percentage of CFF for subgrade soil stabilization from the above study is 0.25%
- It can be concluded that the CFF cannot be used for constructing high quality subgrade but can be used in sub grade for approach roads to construction sites, as it is a cost effective method as well as it becomes a part of waste management.

APPENDIX

Table 1: Observation of sieve analysis test on soil

I s sieve size	wt. retained in gm	% wt retained	Cumulative % wt retained	%PASSING
4.75	0.1	0.0033	0.0033	93.5
2.36	12	0.4	0.4	99.6
1.7	21	0.7	1.1	98.9
1.18	50	1.67	2.8	97.2
1	170	5.67	8.4	91.6
0.6	358	11.9	14.7	85.3
0.425	658	21.9	36.64	63.36
0.3	550	18.33	54.97	45.03
0.15	600	20.0	75.0	25.0
0.075	425	14.2	89.14	10.86
Pan	155.9	5.20	94.33	5.67

Table 2. Observation of liquid limit on soil

Container Number	**1**	**2**	**5**	**6**
Number of blows	26	30	10	5
Weight of container(w1)	35.57	30.11	33.78	36
Weight of container +wt. of wet soil(w2)	37.68	33.45	35.73	38.2
Weight of container +wt. of dry soil(w3)	37.59	33.38	35.33	37.4
Weight of dry soil w3-w1	2.02	3.27	1.55	1.4
Weight of water w2 -w1	2.11	3.34	1.95	2.2
water content=(w2 -w1)*100/(w3 -w1)	104.46	102.14	125.81	157.1

Table 3. Observation of plastic limit on soil

Container Number	1	2	3
Weight of the container (M1)	35.56	30.12	36.32
Weight of the container + wet wt of the soil(M2)	37.27	31.66	37.58
Weight of the container + dry wt (M3)	36.92	31.33	37.33
Mass of the water(M2-M3)	0.35	0.33	0.25
Mass of dry soil (M3-M1)	1.36	1.21	1.01
Water content (W)	0.26	0.27	0.25
Average	25.74	27.27	24.75

Table 4: Observation of CBR on virgin soil

penetration in mm	proving ring reading	load in kg
0.5	31	174.22
1	50	281
1.5	65	365.3
2	82	460.84
2.5	107	601.34
3	110	618.2
4	131	736.22
5	151	848.62
7.5	199	1118.38

10	241	1354.42
12.5	282	1584.84

Table 5: Observation of CBR on 0.1% CFF added soil

penetration in mm	proving ring reading	load in kg
0.5	28	157.36
1	49	275.38
1.5	79	443.98
2	99	556.38
2.5	108	606.96
3	120	674.4
4	135	758.7
5	144	809.28
7.5	150	843
10	164	921.68
12.5	170	955.4

Table 6: Observation of CBR on 0.25% CFF added soil

penetration in mm	proving ring reading	load in kg
0.5	21	118.02
1	49	275.38
1.5	66	370.92
2	85	477.7
2.5	112	629.44
3	120	674.4
4	134	753.08
5	153	859.86
7.5	190	1067.8
10	223	1253.26
12.5	261	1466.82

Table 7: Observation of CBR on 0.5% CFF added soil

penetration in mm	proving ring reading	load in kg
0.5	5	28.1
1	20	112.4
1.5	38	213.56
2	54	303.48
2.5	72	404.64
3	79	443.98
4	85	477.7
5	94	528.28
7.5	100	562
10	106	595.72
12.5	115	646.3

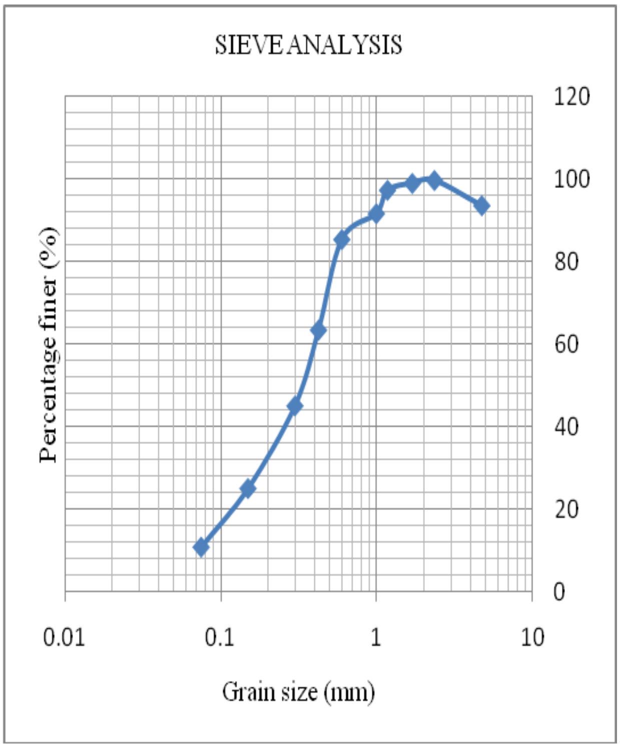

Fig 4: sieve analysis curve

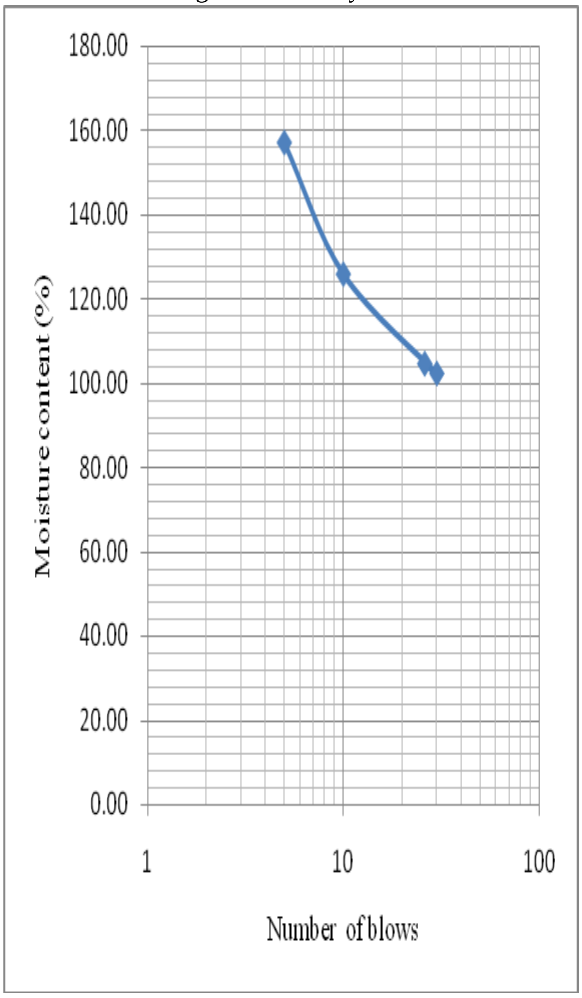

Fig 5: Graph of liquid limit

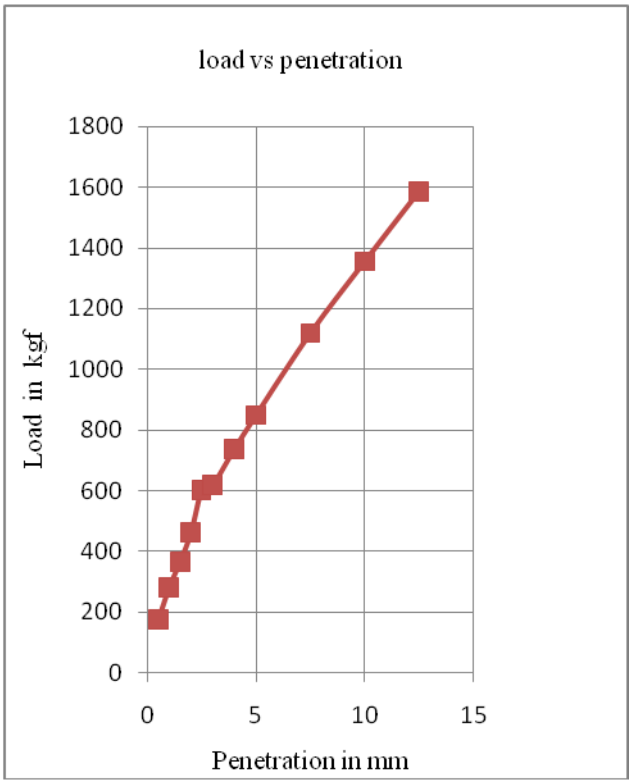

Fig 6: Load Penetration curve

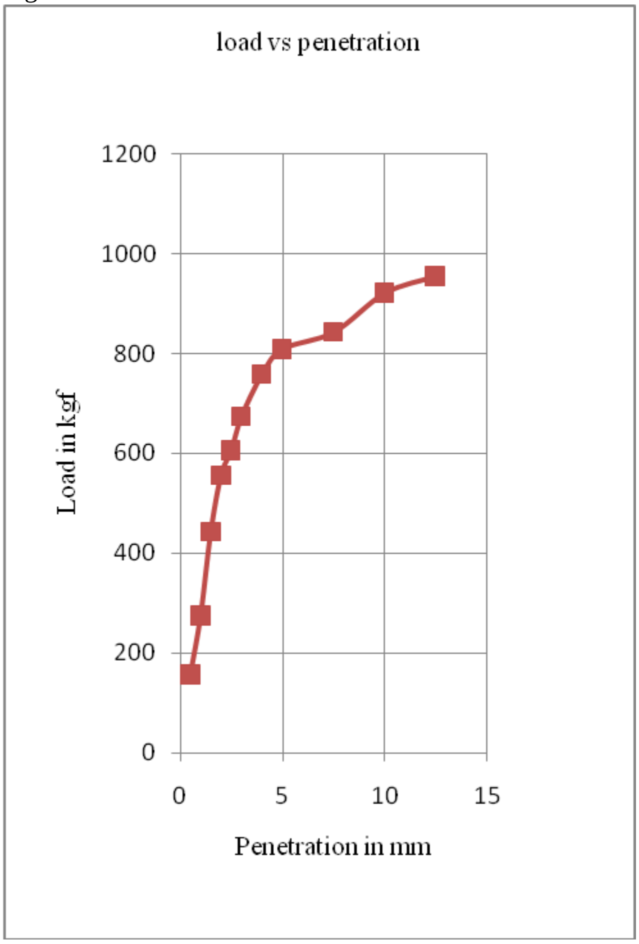

Fig 7: Load Penetration Curve For 0.1% CFF added Soil

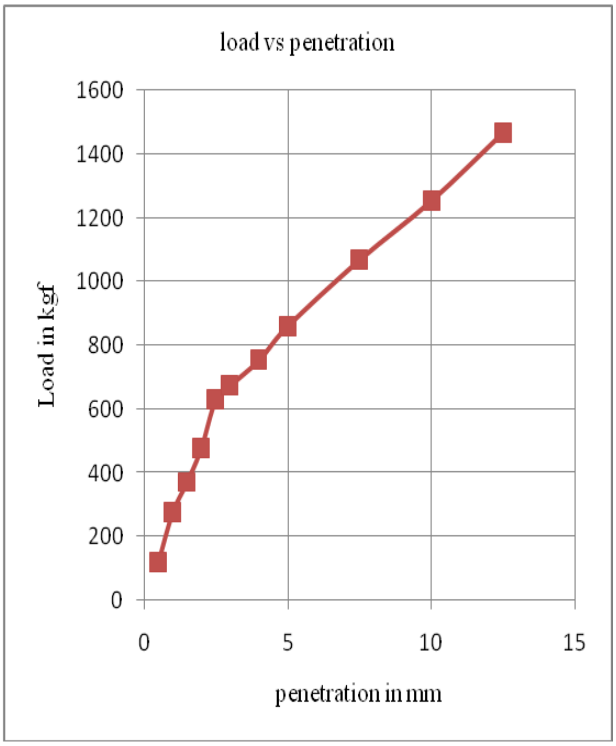

Fig 8: Load Penetration Curve For 0.25% CFF added Soil

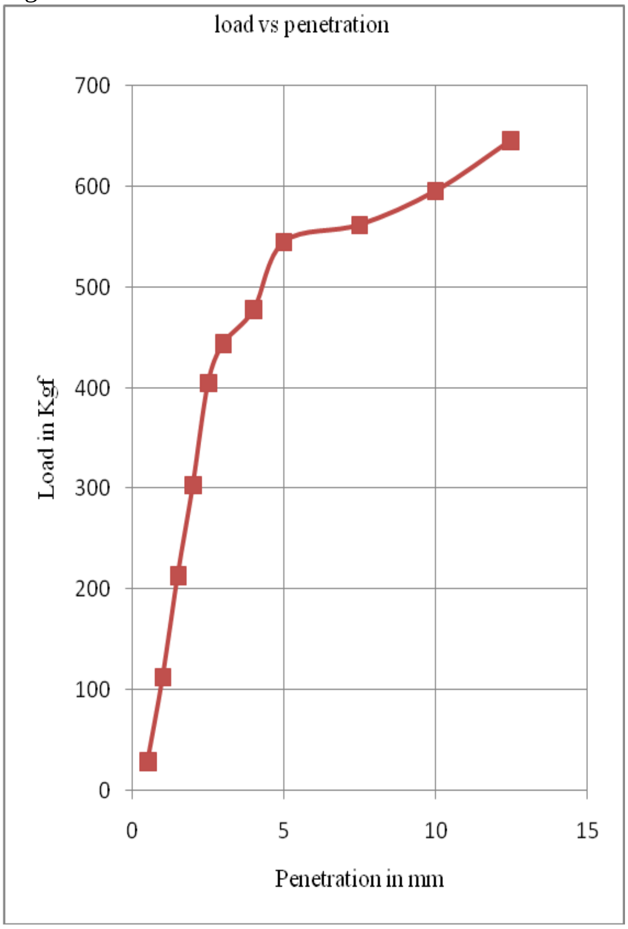

Fig 9: Load Penetration Curve For 0.5% CFF added Soil

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