Determination of Variation of OMC Characteristic Due to Soil Stabilization

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Abstracts: Generally the soil quality improvements through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and in strength. The tensile strength and stiffness of a soil layer can be improved through the use of additives and thereby permit a reduction in the thickness of the stabilized layer and overlying layers within the pavement system. According to Sherwood (1995) and Little (1999), lime stabilization can be used to either modify or stabilize clays. The strength of lime mixture depends to a great extent on the quantity of lime added above lime fixation point. (i.e. it changes the Plasticity Index of soil). In this experiment Indian A-7a type black cotton sol is used. In this paper soil subgrade characteristics are determined by using 0%, 2%, 4%,6%, 8%, 10%, 12%, lime (by weight of soil) stabilization techniques & a graphical representation is made % of stabilization Vs optimum moisture content & maximum dry density values. But some time in the field OMC of soil, especially black cotton soil changes very rapidly in this case the advantage of this graph is one can easily get a rough idea about changes soil characteristics due to applications of lime stabilization, when the soil becomes highly plastic to non plastic. Finally a semi empirical formula is made to get an idea about OMC & Maximum Dry Density values of A-7a type Indian black cotton soil (As per Highway Research Board of India) due to application of lime stabilization within range of 0 to 12% of lime by weight of soil. This paper also help full to determine how the subgrade strength varies with lime stabilization.

KYE WORDS: *Sub-grade Soil Stabilization, Lime Stabilization, Changes in Soil Characteristics due to Lime Stabilization, Establishment of Semi Empirical Formula, Limitations*

SOIL STABILIZATION

Pavements are usually designed based on the assumption that specified levels of quality will be achieved for each soil layer in the pavement system. Each layer must resist shearing within the layer, avoid excessive elastic deformations that would result in fatigue cracking within the layer or in overlying layers, and prevent excessive permanent deformation through densification. When the quality of a soil layer is increased its ability to distribute the load over a greater area is generally increased enough to permit a reduction in the required thickness of the soil and surface layers. Generally, the soil quality improvements through stabilization include better soil gradation, reduction of plasticity index or swelling potential, and increases in durability and in strength. The tensile strength and stiffness of a soil layer can be improved through the use of additives and thereby permit a reduction in the thickness of the stabilized layer and overlying layers within the pavement system.

Lime Stabilization:- Lime can be used to treat soils to varying degrees, depending upon the objective of the stabilization for a specific project. The least amount of treatment is used to dry and temporarily modify soils (Sherwood, 1995). Such treatment produces a working platform for construction or temporary roads. The highest amount can be used when it is being used to improve the soil strength properties for supporting roads (Sherwood, 1995). Lime stabilization is a widely used means of chemically transforming unstable soils into structurally sound construction foundations. Lime stabilization enhances engineering properties in soils, including improved strength; improved resistance to fracture, fatigue, and permanent deformation; improved resilient properties, reduced swelling, and resistance to the damaging effects of moisture. The most substantial improvements in these properties are seen in moderately to highly plastic clays (Little, 2000).

According to Sherwood (1995) and Little (1999), lime stabilization can be used to either modify or stabilize clays. The strength of lime mixture depends to a great extent on the quantity of lime added above lime fixation point. It is generally found that beyond a certain % of lime the increase in strength ceases & in fact a lowering strength may result due to present of unreacted free lime indicating that there exists optimum lime content for maximum strength grain. So after a certain limit of lime content no development of strength but cost increases. As per Illinois Department of Transportation (2005) for lime modification, the optimum lime content is the percent lime that provides a minimum immediate bearing value (IBV) of 10 percent. For lime stabilization, the optimum lime content is the percent lime that results in a stabilized soil strength gain of 50 psi, so required thickness of granular layer should be reduced by using the optimum quantity of lime stabilizer. But use of optimum quantity of stabilizer is not always economical. The optimum amount of lime for maximum strength gain in stabilizing soil with lime, according to Eades and Grim (1960) is 4 - 6 % for Kaolinite, about 8 % for illite and montmorillonite. Ola (1978) found a linear relationship between the strength of lime – stabilized black Cotton soil and lime content (up to 10 % lime). But in those literatures, authors have not determined the optimum lime requirement to satisfy the cost effectiveness of pavement construction. Generally authors have considered only strength development without considering the cost effectiveness. As per IRC 51-1992 optimum lime content for soil;

Kaolinitic soil	4%
Illitic soil	8%
Montmorillonitic soil	10%

TEST RESULT *Basic Properties of soil*

1. Specific Gravity	2.66
2. % finer than 4.75mm	100
3. % finer than 75μ	96.83
4. Liquid Limit	63.8%
5. Plastic Limit	34.37%
6. Plasticity Index	29.43%
7. Flow Index	13.3%
8. OMC	31.95 %
9. Maximum Dry Density	14.36 KN/m^3
10. Bulk Density	18.94 KN/m^3
11. Elastic Modulus	2.7267 Mpa
12. Φ value of sample	2.22 deg
13. Cohesion Value	0.452 kg/cm^2
14. Type of black cotton soil (as per HBR)	A-7a
15. General Rating as Sub-Grade (as per HBR)	Poor
16. Suggested Chemical stabilizer	Lime (IRC 51-1992)

Test Result Application of Lime Stabilization

APPLICATION OF LIME STABILIZATION	PLASTIC LIMIT %	LIQUIED LIMIT %	PLASTICITY INDEX %	OPTIMUM MOISTURE CONTENT %	MAXIMUM DRY DENSITY KN/m^3	BULK DENSITY KN/m^3
0%	34.37	63.80	29.43	31.95	14.36	18.94
2%	39.54	67.50	27.96	32.90	14.06	18.69
4%	42.91	68.00	25.00	33.50	13.98	18.68
6%	45.97	70.00	24.03	34.40	13.89	18.67
8%	46.84	70.48	23.52	36.50	13.67	18.65
10%	48.96	71.00	22.04	38.00	13.50	18.63
12%	50.36	71.96	21.06	38.50	13.02	18.03

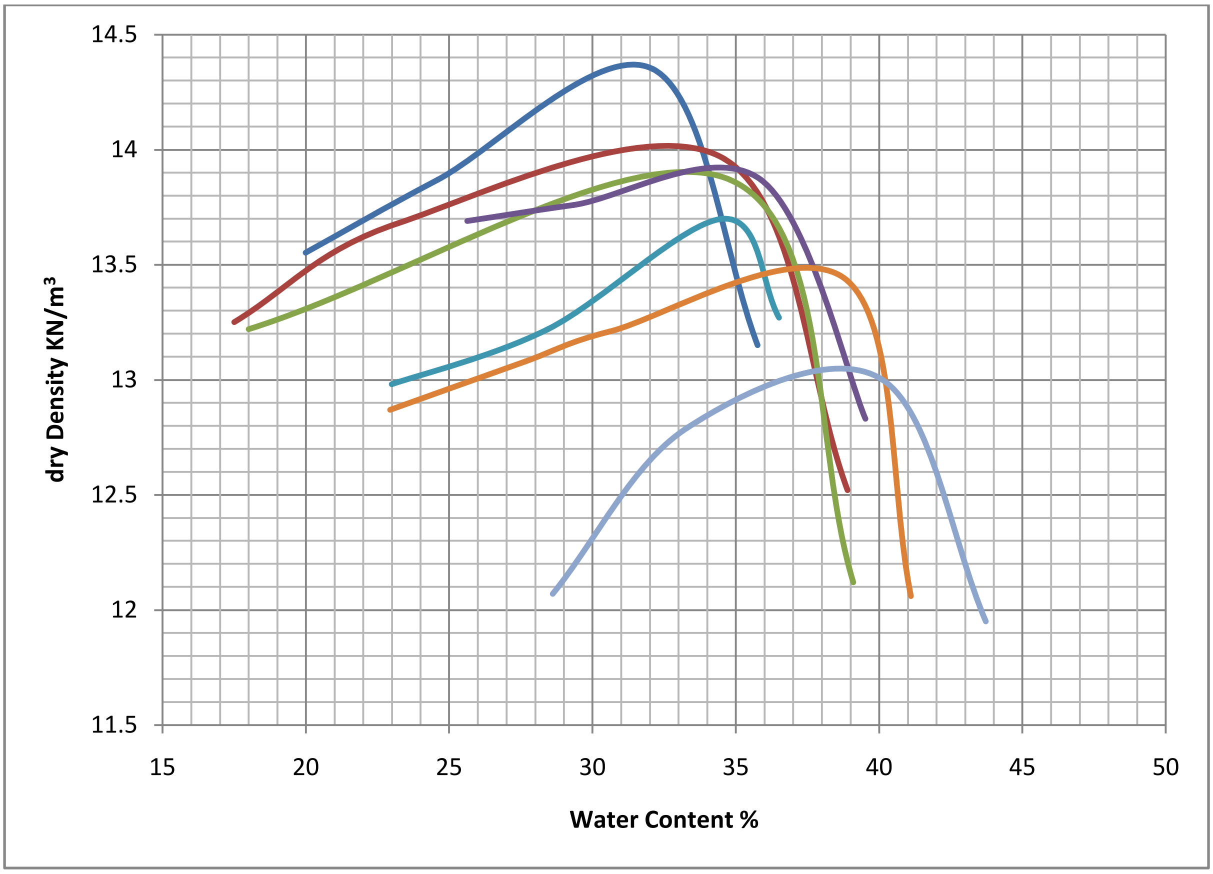


Figure 1 Dry Density Vs Moisture content curve

0% Lime 2% Lime 4% Lime 6% Lime 8% lime 10% lime 12% Lime

Influences on OMC Due to Application of Soil stabilization

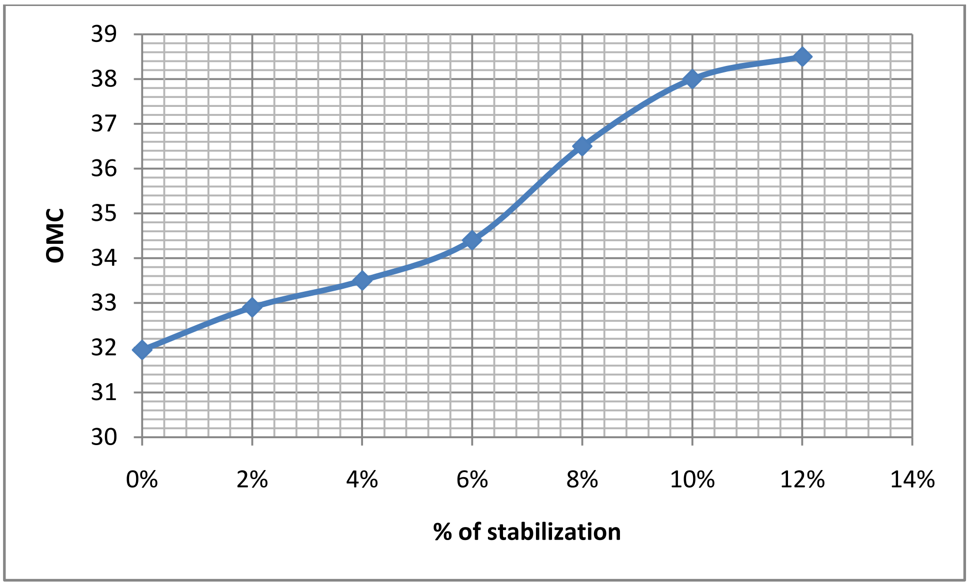


Figure 2 OMC VS % Stabilization

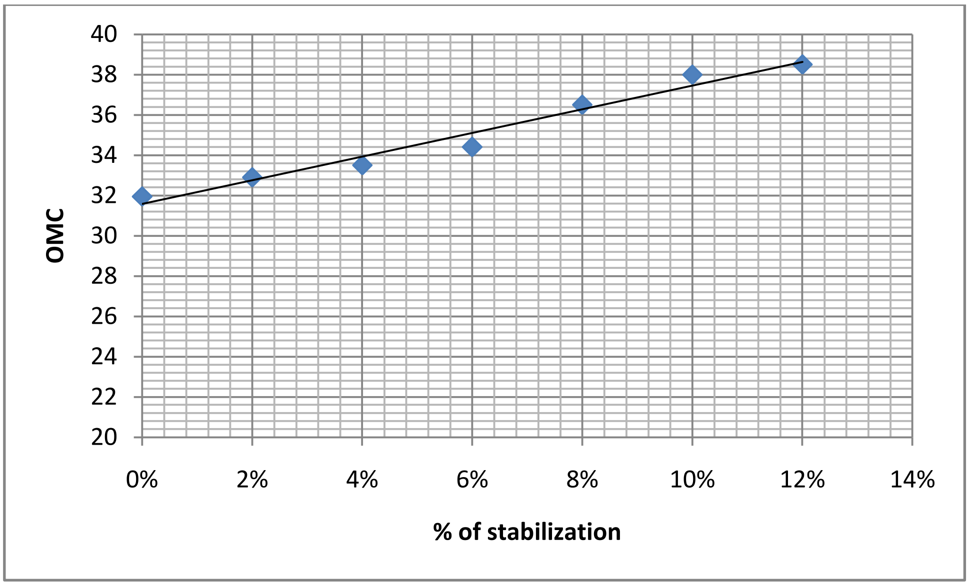


Figure 3 OMC VS % Stabilization (Linear Relationship)

Influences on Maximum dry density Due to Application of Soil stabilization

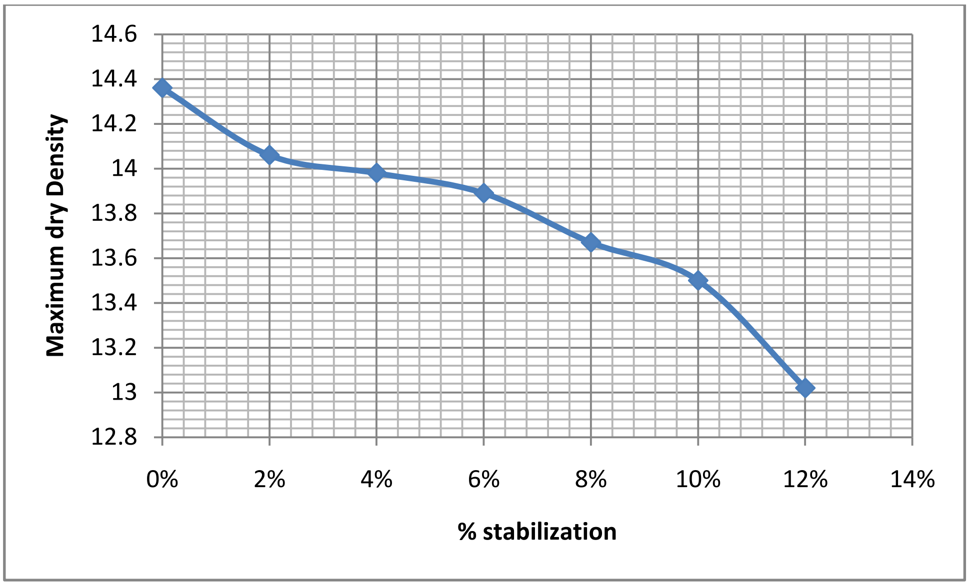


Figure 4 Maximum Dry Density Vs % Stabilization

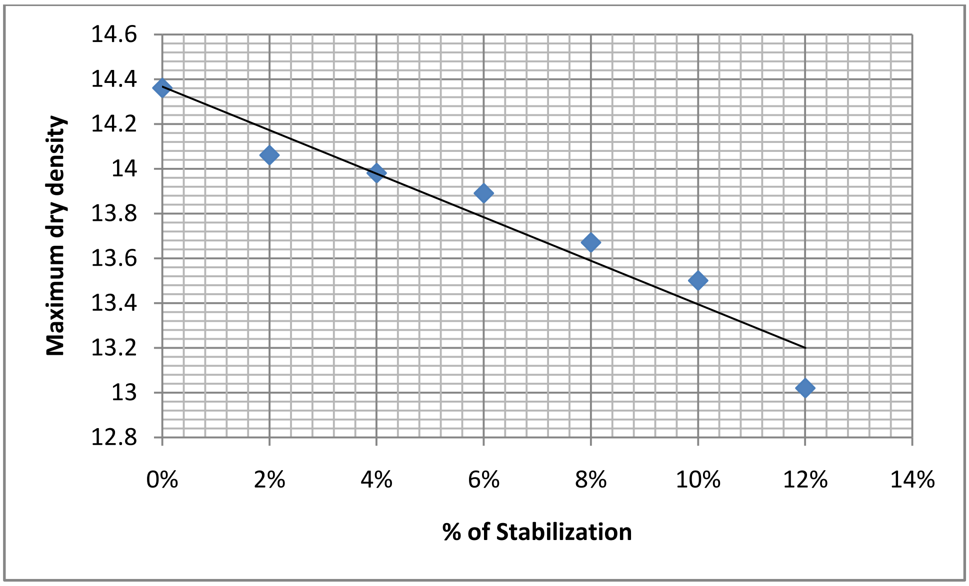
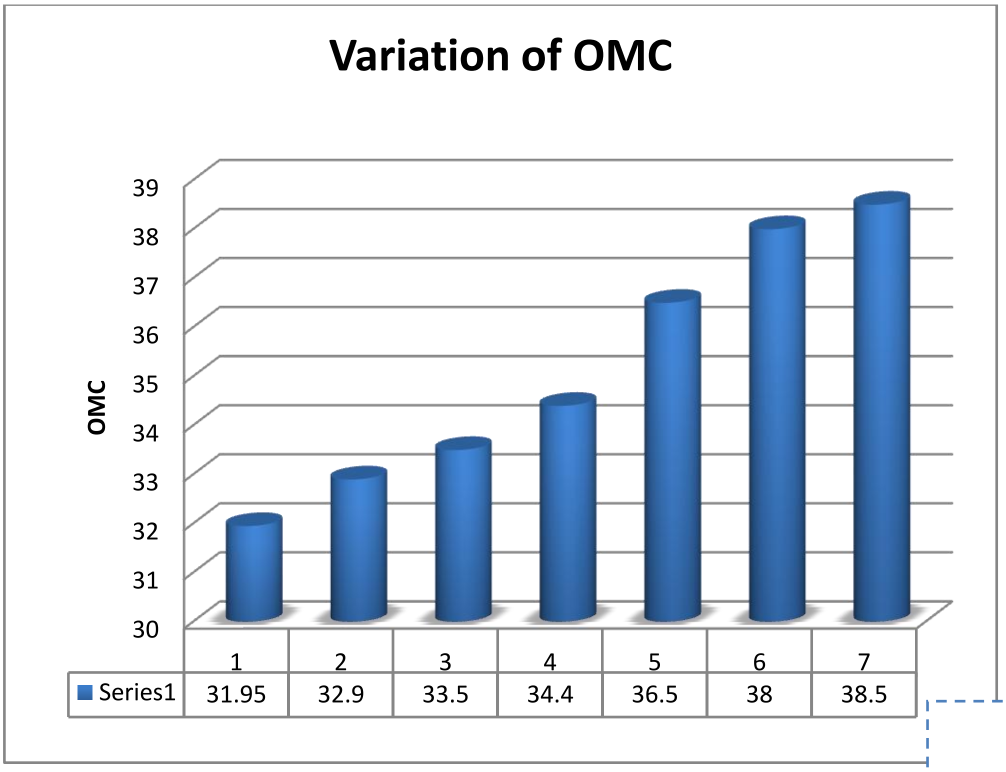
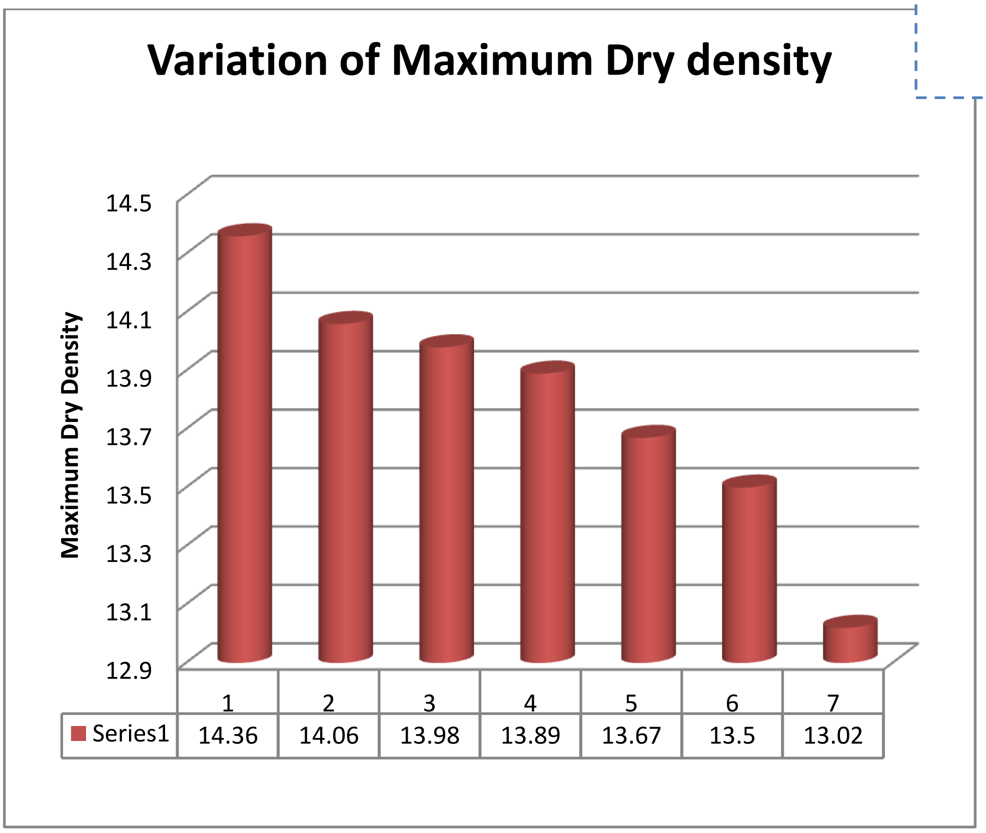


Figure 5 Maximum Dry Density Vs % Stabilization (linear Relation ship)



1- 0% Lime
2- 2% Lime
3- 4% Lime
4- 6% Lime
5- 8% lime
6- 10% lime
7- 12% Lime



Mathematical Relation

The mathematical relationship between OMC of this kind soil & % of stabilization

When Change of OMC due to application of soil stabilization assume as *linear*;

a = 0.546b + c – d

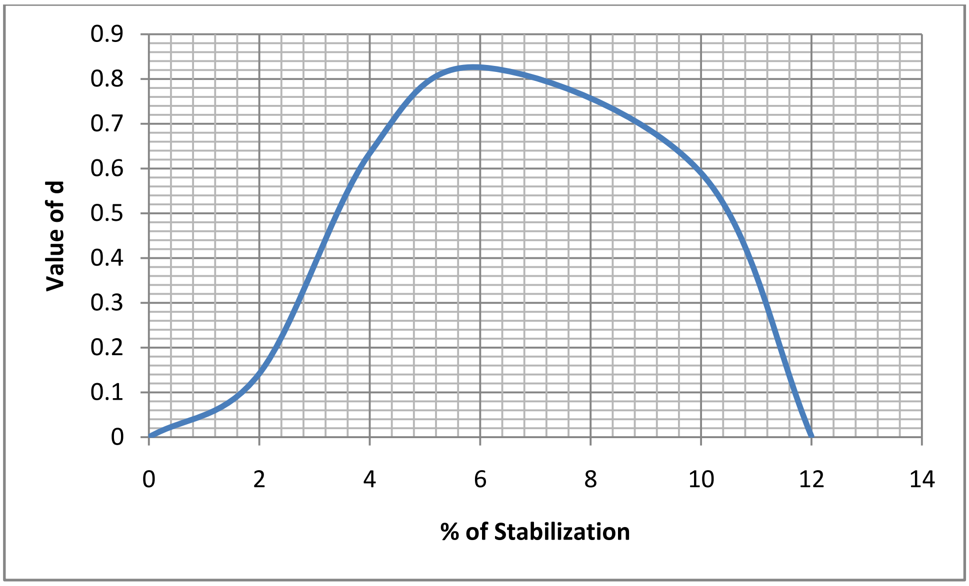
where,

a is the OMC of soil due to application of soil stabilization

b is the % of stabilization applied

c is the initial value of OMC

d is regression constant obtained from graph below



The mathematical relationship between Maximum Dry Density of this kind soil & % of stabilization

When Change of OMC due to application of soil stabilization assume as *linear*;

a = -0.0967b + c ± d

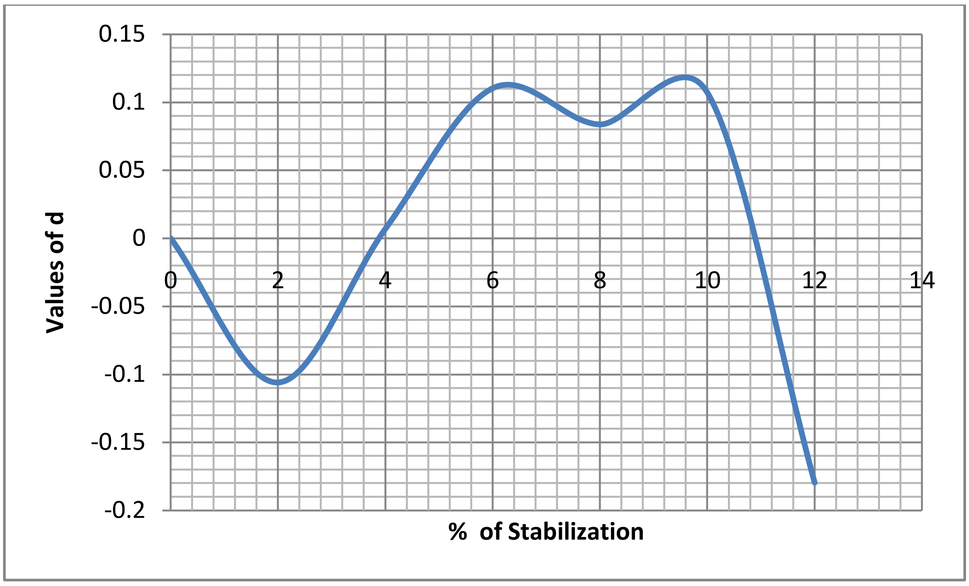
where,

a is the MDD of soil due to application of soil stabilization

b is the % of stabilization applied

c is the initial value of MDD

d is regression constant obtained from graph below



TEST RESULT ANALYSIS:

As per IRC 51-1992 optimum lime content for soil;

Kaolinitic soil	4%
Illitic soil	8%
Montmorillonitic soil	10%

so, by using the formula & design chart we can get an rough idea about OMC & MDD value of A-7a type black cotton soil by using 0 to 12% of application of lime stabilization.

Limitations of the Experiment

- ✓ This formula applicable only for specific type of black cotton soil
- ✓ Lime range limited only 0 to 12%
- ✓ Values of regression constantans may be in negative
- ✓ There may be some positive or negative errors
- ✓ Initial OMC & γ_d value for this type of soil should be determined by proper lab experiment

Conclusion

Although there are many limitations but the formula gives an idea about OMC value of A-7a type black cotton soil (As per Highway Research Board of India) due to application of lime stabilization within range of 0 to 12% of lime by weight of soil. This paper also help full to determine how the subgrade strength varies with lime stabilization.

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