International Journal of Engineering Research & Technology (IJERT)
ISSN: 2278-0181
Vol. 4 Issue 05, May-2015

Evaluation of Construction Materials for Soil Stabilization in Road Making Industry – A Techno Economic Study

Sovina Sood
Professor,Civil Engineering Department,
PEC University of technology
Chandigarh (INDIA)

Shikha Bansal
Student, ME Transportation Engg.
PEC University of technology
Chandigarh (INDIA)

Abstract: **Poor subgrade soil conditions can lead to inadequate pavement support and reduce pavement life. Soils may be improved by soil stabilization by stabilizing by lime, fly ash, cement, rice husk, etc. which are generally waste products and they create disposal problems. These additives can be used with a variety of soils to help improve their engineering properties. The effectiveness of these additives depends on the soil treated and the amount of additive used. The subgrade strength is mostly expressed in terms of California Bearing Ratio (CBR). Weaker subgrade essentially requires thicker layers whereas stronger subgrade goes well with thinner pavement layers. The pavement and the subgrade mutually must sustain the traffic volume. This work attempts to understand the strength of subgrade in terms of CBR values subjected to different types of stabilizers. Treatment with lime and fly ash was found to be an effective option for improvement of soil properties, based on the testing conducted as a part of this work. It was found that with the addition of stabilizers i.e. lime and fly ash, the C.B.R. increased upto a certain limit but after that the C.B.R. decreased even on the further addition of stabilizers.**

Keywords: Subgrade, pavement, stabilizer fly ash, lime, California Bearing ratio.

I.INTRODUCTION

Roads form the part of the basic infrastructure for a nation and in a developing country like India where distances between two major cities can be a couple of thousand kilometres, roads can be actually termed as lifeline of the nation. Constructing roads for everyone's need and maintaining the vast network, make considerable demand on construction material, India is a vast country where roads serve the purpose of connecting one region to another, one state to another and one metro to another. Road network system of India is important if we want to become an economic superpower. Today there is the need to create more roads, broaden the existing ones and to make them safer so that India is on the road to become a developed nation.

II.OBJECTIVE AND SCOPE OF STUDY

A.Objective

Since the research attempts to study the construction materials used in road making, it required the collection of following secondary data

- Research Institute (CRRI), IRC, BIS.
- Research also attempts to evaluate for CBR (California Bearing Ratio) for soil specimen and by addition of stabilizers and reducing the pavement thickness and thus the cost. Thus the following experiments were conducted:
- Addition of different percentage of lime as stabilizer and calculation CBR for each specimen and thus finding the optimum quantity of lime.

B.Scope

- Replacement of soil with fly ash and lime as stabilizer and calculation CBR for each specimen and thus finding the optimum quantity.
- To collect various soil samples from different sites of work and to find its basic physical properties such as plastic limit, liquid limit, and grain size distribution.
- To study the soil and determine the optimum moisture content (OMC) and maximum dry density (MDD) for the soil sample.
- To conduct CBR test on Soil sample

Evaluating for pavement thickness and saving in pavement material by use of soil stabilizers.

III.REVIEW OF LITERATURE

Following literature is carefully reviewed and studied by the researcher

1. R.Ramakrishnan in his paper on "Relevance of Privatization to Road Development" has depicted that the number of vehicles on road has overtaken road development. This has increased the congestion, pollution and accidents. The years ahead are poised for tremendous growth. So in the coming years there will

be a great demand for road material for quality road making. Cost economics and design of roads with reference to construction materials will have to be evaluated critically.

2. The latest edition of the well known reference book 'Indian Economy', by Ruddar Datt and K.P.M. Sundharam was read, especially the chapters on the infrastructure in India. It helped in understanding the importance of transport, especially the road transport, for development of all the sectors in the Indian economy. It also guided to realize and understand various issues related to road transport.
3. Satyanarayana *et al.* (2004) studied the combined effect of addition of fly ash and lime on engineering properties of expansive soil and found that the optimum proportions of soil: fly ash: lime should be 70:30:4 for construction of roads and embankments.
4. Phani Kumar and Sharma (2007) studied the effect of fly ash on swelling of a highly plastic expansive clay and compressibility of another non-expansive high plasticity clay. The swell potential and swelling pressure, when determined at constant dry unit weight of the sample (mixture), decreased by nearly 50% and compression index and coefficient of secondary consolidation of both the clays decreased by 40% at 20% fly ash content
5. Buhler *et al*. (2007) studied the stabilization of expansive soils using lime and Class C fly ash. The reduction in linear shrinkage was better with lime stabilization as compared to same % of Class C fly ash

A .Construction material in road making

Engineers have been always with open mind to adopt any material available to them for its use for the construction purposes Research facilities at hand help them to judge the suitability of the materials. The binders employed are mainly soil slurry, bituminous material and cement. Construction Materials, which are commonly used in road making, are

- Soil
- Aggregates
- Bitumen
- Cement
- Miscellaneous materials (Steel, Water, Admixtures, Geo-textiles, Geo-grids)

1 .Soil

a. Importance of soil in Highway Engineering

The bulk of the material used in highway embankment is soil. Soil is also used in pavement structure either in its natural form or in its processed form (stabilized soil). Soil is also used as a binder in Water Bound Macadam layers.

b. Soil strength

Knowledge of the strength of a soil is extremely important since the pavement and foundation of structure rests on soil. The stability of the pavement and the structures is governed by the strength of the soils. Difficulties arise in proper evaluation of the strength because soils are seldom uniform in character a number of factors influence the strength property.

c. Method of determination of strength parameters

Basically, the method of determination of soil strength falls in three groups:

The most commonly used test for the design of flexible pavement is the California Bearing Ratio test abbreviated as CB. The test is basically a penetration test, in which the load is required to cause a plunger of standard size to penetrate a specimen of soil at standard rate. The test can either be conducted on remoulded specimens of undisturbed specimen in the laboratory or in-situ on the subgrade soil itself

Some typical values of CBRs of Indian soil are:

TABLE 1 DIFFERENT TYPES OF SOIL AND CBR VALUES

Soil type	CBR value
Black cotton soil and heavy clays	1 to 2
Alluvial soil	2 to 5
Sandy clay	3 to 5
Dune sand	4 to 6
Well graded sand	6 to 8
Murram (gravel)	8 to 20

2. Aggregates

Aggregate is the major component used in road making. It is used in granular bases and sub-bases, bituminous courses and in cement concrete pavements.

Aggregates are broadly classified as coarse aggregates and fine aggregates. Fine aggregates are those most of which pass 4.75 mm sieve, and coarse aggregates are those most of which are retained on 4.75 mm sieve.

Fine aggregates are generally obtained as natural sand from river beds. They can also he obtained by crushing stone and gravel. Coarse aggregates can either be]

a. uncrushed gravel

b. crushed stone or gravel

c. a blend of the two

Gravel is obtained in a natural state from gravel pits, river beds or glacial deposits.

There are many tests which are conducted to check the quality of aggregates. Aggregates are very important component of concrete, so the quality really matters when it comes to aggregates.
Various test which are done on aggregates are listed below.
1. Sieve Analysis.
2. Water Absorption
3. Aggregate Impact Value
4. Aggregate Abrasion Value
5. Aggregate Crushing Value

3. Bitumen

As early as 5000 years ago, bitumen was used by man as waterproofing and bonding agent. The use of bitumen on roads in recent times picked up in nineteenth century. Natural rock asphalt was initially used, but as petroleum distillation began to grow as an industry to fuel the road vehicles, the residue found equally increasing use in constructing better roads.

a. Bitumen tests

- Penetration
- Softening point
- Temperature susceptibility
- Ductility
- Heat stability

4. Cement

Cement is a material obtained by pulverizing clinker formed by calculating raw materials, primarily consisting of argillaceous and calcareous materials. The argillaceous materials used are shale, clay and blast furnace stag. The calcareous material commonly used is limestone. These materials supply the essential components such as Limestone (CaO), Silica (SiO_2), Alumina(Al_2O_3) and Iron Oxide(Fe_2O_3). Cement when mixed with water, forms a paste, which hardens and binds the particles of aggregates together to form a hard durable mass called concrete. Ordinary cement is called Portland cement because of resemblance of set cement to rock formed on the English Island of Portland. With a current production capacity of around 366 million tonnes (MT), India is the second largest producer of cement in the world.

A .properties of cement

The following are some of the main properties of cement which are of importance to highway engineers:

- Fineness
- Setting time
- Soundness
- Compressive strength
- Tensile strength
- Specific gravity
- Consistency

B. Soil Stabilization

Soil stabilization is a collective term for any physical, chemical, or biological method, or any combination of such methods that may be used to improve certain properties of a natural soil to make it serve adequately an intended engineering purpose. It is the process of blending and mixing materials with a soil to improve certain properties of the soil. The process may include the blending of soils to achieve a desired gradation or the mixing of commercially available additives that may alter the gradation, texture or plasticity, or act as a binder for cementation of the soil. The main benefits of using lime to stabilize clays are improved workability, increased strength, and volume.

1.Lime Stabilization

Lime Stabilization is done by; adding lime to a soil. Lime increases the optimum water content for compaction, which is an advantage when dealing with wet soil. The compaction curve for lime-treated clay is generally flatter, which makes moisture control less critical and reduces the variability of the density produced Lime increases the strength of clayey soil. Related to strength is improved durability under traffic or resistance to the action of water, wind, and freeze-thaw cycles. The shrinkage and swell characteristics of soil are reduced markedly.

2.Fly Ash Stabilization

Fly ash is a waste product from coal burning utility plants and is available in form of fine dust. It is the grey dust like ash obtained as residue from the burnt powdered coal
Fly ash is made up of mainly tiny sphere of silica and alumina glass and small free lime. It has very good physical and chemical properties such as fineness (finer then cement) and pozzolanic activity (greater than many natural and artificial pozzolans). It is postulated that fly ash will be stabilize the soil chemically as well as mechanically. When clayey soils are treated with fly ash, it

is believed that the stabilization occurs mainly due to the presence of free lime in the fly ash which reacts chemically with silica and alumina to make the soil more stable. On the other hand, with coarser soils it is likely to act in both ways as lime acts with the silica and alumina present in fly ash and binds the coarser particles also help the coarse sand particles in mechanical stabilization, by filling the voids in sands particles so as to make the mix more dense resulting in the higher strength.

IV. EXPERIMENTAL STUDIES

A.Atterbergs limits

TABLE 2: LIQUID LIMIT

Number of blows	Water content
13	39.28
15	38.02
23	36.61
28	28.73
35	26.82

Liquid limit at 25 blows = 33.13%

TABLE 3: PLASTIC LIMIT DETERMINATION OF SOIL

Wt. of crucibles (gm)	Water content %
12	25.33
10	21.42
6.3	19.50

Plastic Limit = 22.08%

Plasticity Index = Liquid Limit– Plastic Limit = 33.13-22.08 = 11.05%

Then from plasticity chart (A-line chart) the soil is classified as CL.

B.Properties of soil with addition of stabilizers

TABLE 4: PROPERTIES OF SOIL WITH ADDITION OF LIME

Lime (%)	OMC %	MDD (gm/cm^3)	CBR (soaked conditions)
3	13.02	1.61	8.62
5	15.72	1.56	10.42
5	19.46	1.46	9.28

TABLE 5: PROPERTIES OF SOIL WITH REPLACEMENT OF FLY ASH

Soil + fly ash (%)	OMC %	MDD (gm/cm^3)	CBR (soaked conditions)
80 + 20	17.48	1.66	3.19
70 + 30	18.42	1.59	3.49
60 + 40	19.42	1.51	2.42
50 + 50	19.98	1.48	2.02

TABLE 6: PROPERTIES OF SOIL WITH REPLACEMENT OF FLY ASH AND LIME

Soil + fly ash +lime (%)	OMC %	MDD (gm/cm^3)	CBR (soaked conditions)
80 + 15 + 5	17.04	1.57	6.62
70 + 25 + 5	17.92	1.48	7.17
60 + 35 + 5	18.94	1.46	7.92
50 + 45 + 5	19.14	1.37	7.17

C. Pavement Thickness and saving of pavement thickness

The thickness of crust varies with the change in the value of C.B.R. With higher value of C.B.R. the crust thickness is less and vice versa. Below shown are the crust thicknesses with different percentages of cement and lime content.

The thickness of crust varies with the change in the value of C.B.R. With higher value of C.B.R. the crust thickness is less and vice versa. Below shown are the savings in crust thicknesses with different percentage of lime and fly ash

TABLE 7: PAVEMENT THICKNESS AND SAVING OF THICKNESS DUE TO STABILIZERS

S.No	Description	Layers	Layer thickness (mm)	Saving in thickness (mm)
1	Soil sample CBR 3%	GSB	380	Design with Base Sample
		G.Base	260	
		DBM	160	
		BC	50	
		TOTAL	850	
2	With lime addition 3%, CBR 8.62%, SAY 8%	GSB	200	180
		G.Base	250	10
		DBM	110	45
		BC	50	0
		TOTAL	615	235
3	With lime addition 5%, CBR 10.42%, SAY 10%	GSB	200	180
		G.Base	250	10
		DBM	110	50
		BC	50	0
		TOTAL	610	240
4	With lime addition 7%, CBR 9.28%, SAY 9%	GSB	200	180
		G.Base	250	10
		DBM	110	50
		BC	50	0
		TOTAL	610	240
5	With soil + fly ash + lime = 80 +15 + 5 %, CBR 6.62%, say 6.5%	GSB	245	135
		G.Base	250	10
		DBM	123	37
		BC	50	0
		TOTAL	668	182
6	With soil + fly ash + lime = 70 +25 + 5 %, CBR 7.17%, say 7%	GSB	230	150
		G.Base	250	10
		DBM	120	40
		BC	50	0
		TOTAL	650	200
7	With soil + fly ash + lime = 70 +25 + 5 %, CBR 7.92%, say 7.5%	GSB	215	165
		G.Base	250	10
		DBM	118	42
		BC	50	0
		TOTAL	633	217
8	With soil + fly ash + lime = 70 +25 + 5 %, CBR 7.71%, say 7.5%	GSB	215	165
		G.Base	250	10
		DBM	118	42
		BC	50	0
		TOTAL	633	217

Figure 1: Crust Thickness With Different Percentages Of Lime Addition

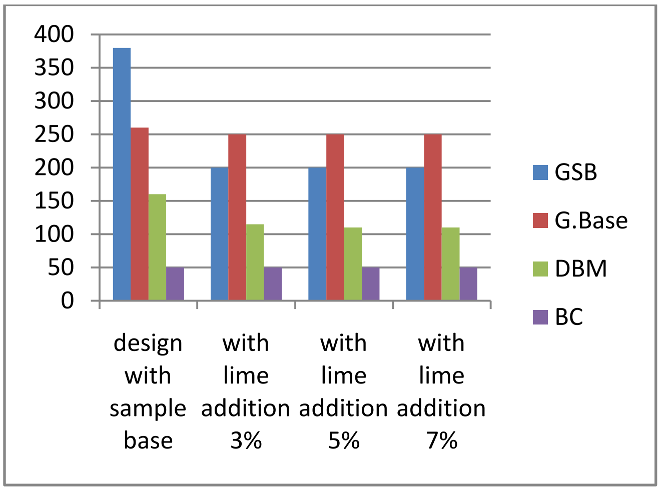
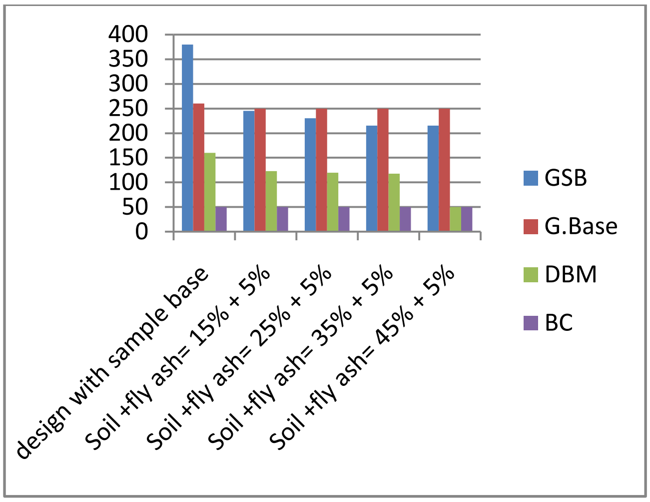


Figure 2: Crust Thickness With Different Percentages Of Fly Ash And Replacement



V.COST ANALYSIS

TABLE 8: COST ANALYSIS IN CASE OF LIME STABILIZATION

Optimum quantity of lime = 5% (max CBR)	
Cost of lime stabilization	
Quantity	600 x 1.78 x1000 x 5/100 = 53400 kg = 53.5 tonnes
Cost of lime per tonne	RS 3000
Cost of lime stabilization per km	53.5 x 3000 = Rs 1,60,500
Approximate Cost including lime-soil blending cost	Rs 1,80,000
Saving of material and cost	
Saving in road thickness*	(850-610) mm = 240 mm
Saving in maerial	0.24 x 1000 x 3 = 720 m^3
cost of compacted sub base material	Rs 290/m^3 to Rs 540/m^3 depending upon its haulage distance.
Total saving	Rs(290-540)/m^3 x (3 x 1000 x 0.425)m^3 = Rs 3,69,750 – Rs 7,39,500

TABLE 9: COST ANALYSIS IN CASE OF LIME STABILIZATION

Optimum quantity of fly ash with lime = 35% +5% (max CBR)	
Cost of stabilization	
Quantity replaced	{600 x [(1.24 x 35/100) +(1.78 x 5/100)] x1000} x 40% = 1,25,520kg = 125.52 tonnes
Cost of fly ash and lime per tonne including haulage	Rs 1500
Cost of lime stabilization per km	125.52 x 1500 = Rs 1,88,280
Approximate Cost including lime-soil blending cost	Rs 2,00,000
Saving of material and cost	
Saving in road thickness*	(850-633) mm = 217 mm
Saving in maerial	0.217 x 1000 x 3 = 651 m3
cost of compacted sub base material	Rs 290/m3 to Rs 540/m3 depending upon its haulage distance.
Total saving	Rs(290-540)/m3 x (3 x 1000 x 0.425)m3 = Rs 3,69,750 – Rs 7,39,500

VI. REFERNCES

1. Phani Kumar S. R. and Sharma R. S. (2004). "Effect of fly ash on engineering properties of expansive soils." J. Geotech. Geoenviron. Eng., 130(7),764–767
2. Cokca, E. 2001 "Use of class C fly ash for the stabilization of an expansive soil." J. Geotech. Geoenviron. Eng., 127. 7. [568–573.
3. Kaniraj S R, Havanagi V.G Geo technical characteristics of fly- ash soil mixtures. Geo technical Engineering journal, 1999, 30 (2) 129-147.
4. Determination of liquid limit and plastic limit. Indian standard methods for testing of soils-IS2720 (a) Indian standard Institution,New Delhi, India, part 5, pp 109-144,1985
5. Bairwa Ramlakhan, Saxena Anil Kumar, Arora T.R 2013 "Effect of lime and fly ash on Engineering Properties of Black Cotton soil" issn 2250-2459, iso 9001:2008 certified journal, volume 3, issue 11, november 2013
6. Government of India. Economic Survey New Delhi: Ministry of Finance,2013
7. Navtaj Singh Dhanoa (2013) "effect of soil stabilizers on the structural design of flexible pavements" masters of engineering in civil-infrastructure engineering thapar university
8. IRC: SP: 72-2007 "Guidelines for the design of flexible pavements for low volume rural road".
9. Indian Highways, Vol.26, No 8 New Delhi Indian Road Congress, August, 2012
10. Dr Pardeep Kumar Gupta techno-economic evaluation of fly ash based subgrade technical research organization, India ISSN:2394-4676,(online):2394-4684,volume-2,issue-1,2015
11. Expert Committee Group, India Infrastructure Report New Delhi: Ministry of Finance, Government of India, 2011Arora N.L., Transportation Engineering, Delhi, New India Publishing House
12. India. Ministry of Road Transport and Highways, Basic Road Statistics of India, 2008-09, 2009-10 and 2010-11, August 2012
13. S.S Maker, Infrastructure, 2000, National Conference on Construction (New Delhi, Construction Industrial Development Council
14. Arora N.L., Transportation Engineering, Delhi, New India Publishing House
15. S.K. Khanna and C.E.G. Justo (2010) Highway Engineering
16. Khanna, S.K & Justo, CEO, Highway Engineering, Roorkee: Nem Chand & Bros, 2001