Research Paper Engineering

Economical Pavement Design by Stabilizing Effect of Fly Ash and Lime

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ABSTRACT

The disposal of solid waste now-a-days is of major concern. Solid waste like flyash is generated in large amounts of 110 million tonnes every year. By using large amount of flyash in pavement construction will bring about economy in pavement design as well as save the fertile soil which can be used for cultivation.

Through our paper we tried to focus on major soils around Pune city. We collected soils from Bhor Village which was of alluvial nature and Katraj Tunnel which was of Black Cotton soil nature. We performed various experiments by taking soil with different percentages of flyash and lime. The percentages are as follows:-

- *Soil (Blank)*
- *Soil + 5% Lime + 10% Flyash*
- *Soil + 5% Lime + 20% Flyash*
- *Soil + 5% Lime + 30% Flyash*

On the basis of tests performed on above percentages we found out that the soils can be stabilized and the pavement was designed using CBR method. By doing this we were able to reduce the pavement thickness for the same strength and hence gained considerable economy.

Keywords :

INTRODUCTION

As we know the road development is one of the major part of growing infrastructure & Pune which is expanding at a very fast rate, the construction of roads is of major concern.

Flyash is one of the abundant forms of Solid Waste produced at thermal power plants. Its disposal is a big problem.

Keeping both these concerns in mind we tried to come out with a project which will integrate Road development and Fly-ash disposal.

Thus, in this project we intend to use Flyash & Lime in roads which will help us in following manner:

- High volumes of Flyash will be used which will save the dumping sites to be used for better purposes.
- The use of flyash will reduce the consumption of high volumes of fertile soil that can be used for cultivation purposes.
- Due to binding properties of lime & Flyash, the pavement designed will be of higher strength.
- Overall thickness of the pavement can be reduced.

METHODOLOGY

We will be conducting the following experiments

1. Moisture content
2. Specific gravity
3. Liquid limit
4. Plastic limit & Shrinkage limit
5. Shrinkage limit
6. Heavy compaction test
7. Differential free swell test
8. C.B.R

Moisture content :–
This is used to determined the initial moisture content of soil as moisture changes soils property ,it is also used in understanding the behavior of soil.

Specific gravity:-
It is an important soil parameter of soil ,and also used in identification and classification of soil.

Liquid limit & Plastic limit :-
It is used for classification of fine grained soil.

Shrinkage limit :–
It is used for understanding swelling and shrinkage properties of soil.

Heavy compaction test :–
It has same use as light compaction but used for highways .

Differential free swell test :–
It is used for finding the relative swelling of soil with respect to swelling in water and polar liquid.

C.B.R –
It is California bearing ratio of compacted soil both soaked and un soaked condition . it is used for pavement design.

Fly ash:-
Fly ash is one of the residues generated in compaction, and comprises the fine particles that rise with the flue gases. Ash which does not rise is termed bottom ash. In an industrial context, fly ash usually refers to ash produced during combustion of coal. Fly ash is generally captured from the chimneys of coal fired power plants, and together with bottom ash removed from the bottom of the furnace is in this case jointly

known as coal ash. Depending upon the source and makeup of the coal being burned, the components of fly ash vary considerably, but all fly ash includes substantial amounts of silicon dioxide (SiO2) (both amorphous and crystalline) and calcium oxide (CaO), both being endemic ingredients in many coal-bearing rock strata.

In the past, fly ash was generally released into the atmosphere, but pollution control equipment mandated in recent decades now require that it be captured prior to release.

Class F fly ash :-
The burning of harder, older anthracite and bituminous coal typically produces Class F fly ash. This fly ash is pozzolonic in nature, and contains less than 10% lime (CaO). Possessing pozzolanic properties, the glassy silica and alumina of Class F fly ash requires a cementing agent, such as Portland cement, quicklime, or hydrated lime, with the presence of water in order to react and produce cementitious compounds. Alternatively, the addition of a chemical activator such as sodium silicate (water glass) to a Class F ash can lead to the formation of a geopolymer.

Lime :-
Lime is a very important building material. It has been in use since ancient times. Even today lime is a very important material not only for building purposes, but also in so many other manufacturing processes.

Properties of Lime :-
Following are the properties of lime which have made it, a very important engineering material.

- It has good plastic properties.
- It gives strength to masonry, when used as mortar.
- It stiffens quiet easily and in short time.
- It is easily workable.
- It has good adhering properties with stone and brick both.
- Its shrinkage is comparatively low and hence masonry in lime mortar is more durable.
- It can withstand moisture easily.

Use of Lime :-
The lime can be used for the following purposes :-

1. As a binding material in mortars.
2. As a binding material in concretes.
3. As an aggregate form of crushed lime stone.
4. For plastering
5. For white washing and also as a base coat for distempers.

Varieties of Lime :-
Depending upon the source, the limes may be of following three varieties :

1. Stone lime: - it is almost pure lime.
2. Kankar lime: - it is impure or adultered lime.
3. Shell lime: - it is the purest form of lime.

Parameter	Gravel	Sand	Silt	Clay	Fly Ash
Specific gravity	2.65 - 2.67	2.65 - 2.67	2.67 - 2.70	2.70 - 2.80	1.90-2.55
Maximum Dry Density (g/cc)	1.76-2.27	1.76-1.84	1.52-2.08	1.44-1.84	0.9-1.60
Optimum Moisture Content (%)	7-18	9-15	10-20	15-30	18-38
Angle of Internal Friction (f)	350-500	27.5°-45°	270 - 350	0-60	30°-400
Permeability (cm/sec)	1	10-1 -103	10-5-10-7	10-7&less	8x10-6-7x10-4

SOILS USED
Black Cotton Soil :-
These soils are highly clayey soils, greyish to blackish in colour found in several states in INDIA. Typical behaviour of these soils under different climatic conditions has made the construction of structures has made the construction of structures on these soils not only expensive, but different and dangerous also.

The Black Cotton soils are found to contain montmorillonite clay mineral which has high expansive characteristics. The colloidal clay content in BC soils is upto 50% and the fraction passing 0.075mm I.S sieve ranges from 70 to 100% and 20 to 60% respectively. BC soils have low shrinkage limit and high OMC. All these properties render the soil to moisture changes, compressible and plastic in nature. In case of these soils there is excessive variation in volume and stability and considerable shrinkage on drying and high swelling pressure.

Of the various methods of stabilisation, the most effective method to stabilize BC soil are by using lime along with suitable additives, when necessary.

- **Coastal Alluvial Deposits:-**

Coastal alluvial plains form when streams transporting sediment from mountainous areas reach low elevations and deposit a large proportion of their sediment load. This occurs due to a decrease in stream gradient, which reduces sediment transport capacity. The extent of coastal alluvial plains is controlled in large part by sea level, and alluvium deposited during previous times of low sea level (for example, during glacial epochs) may now lay tens or hundreds of meters below sea level.

Fly Ash-Lime Stabilization :-
When clayey soils with high plasticity are treated with lime, the plasticity index is decreased and the soil becomes friable and easy to be pulverised. When clay is treated with lime the various possible reactions are coagulation, Base Exchange etc. The maximum dry density of soil-lie mix is decreased by 2-3% in terms of untreated soils. Soil-Lime is suitable in warmer regions but not much in cold conditions.

DESIGN OF PAVEMENTS
Introduction:-
The pavements in general are classified as 'Flexible and rigid' according to their structural action. This black top pavement including gravel and water bound macadam fall in the flexible group and the cement concrete pavement is the popular example of the rigid group.

Types of Pavement Structures:-
As mentioned earlier, based on the structural behaviour, pavements are generally classified into two categories.

1. Rigid Pavements
2. Flexible pavements

1. Rigid Pavements :-
Rigid pavements are made up of Portland cement concrete. Because of rigidity and high tensile strength a rigid pavement tends to distribute the load over a relatively wide area of foil and a major portion of structural capacity is supplied by the slab itself. Here the design is entirely based on the consideration of Indian Road Congress (I.R.C).

2. Flexible Pavements:-
Flexible pavements have a self healing power. It reflects the deformation of the subgrade and subsequent layers on the surface. Flexible pavement consists of a series of layers with the highest quality materials at or near the surface. Since, it functions mainly by way of load distribution through components. Layers which gradually reduces reaching the sub grade so as to be within the limits of safe bearing capacity.

Therefore, thickness design requirements in case of flexible pavements are greatly influenced by the sub grade strength.

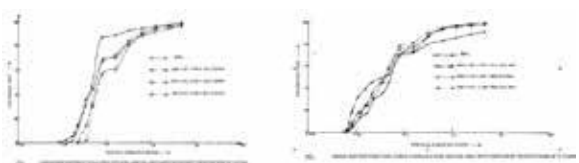
Pavement Structure:-
The pavement structure mainly consists of:-

1. Soil-subgrade
2. Sub-base
3. Base course
4. Wearing course

Design of Flexible Pavement:-
The design of flexible pavement has been done by the following method :-

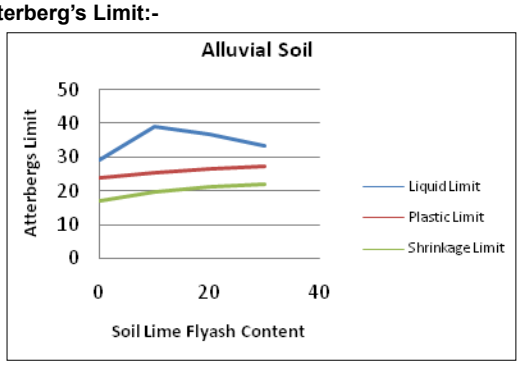
a) Group Index Method
b) California Bearing Ratio Method
c) Triaxial Method
d) McLeod Method
e) Burmester Method
f) Slabinometer Method

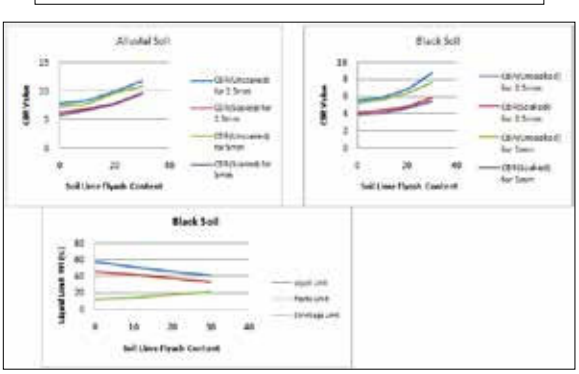
We have designed the pavement by California Bearing Ratio method.



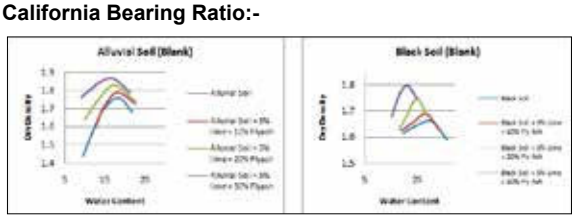
PRESENTATION OF RESULTS: -
Sieve Analysis:-

Atterberg's Limit:-

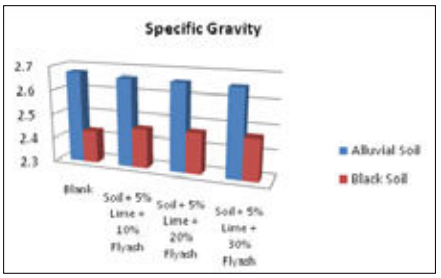




California Bearing Ratio:-



SPECIFIC GRAVITY:-



Conclusion, Suggestion and Scope of Future Investigation

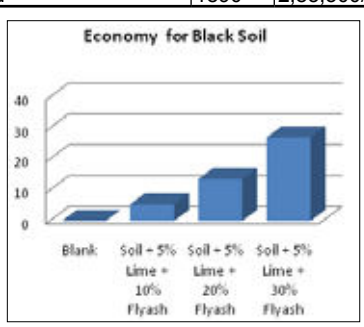
Conclusions
The Alluvial Soil from Bhor Ghat and Black Cotton Soil from near Katraj Tunnel have different properties. These soils when mixed with Lime & Flyash in different proportions have shown us considerable results in Pavement design.

The overall economy achieved as calculated in the above table shows us a considerable results.

Maximum economy achieved is around 35 % regarding all excluded factors.

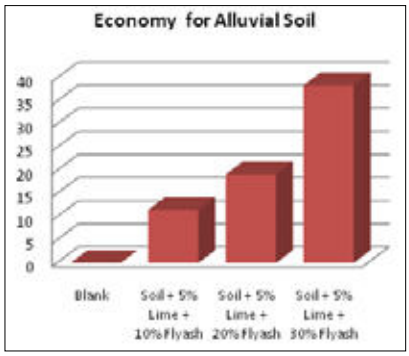
Economy Achieved:-
Black cotton Soil:-

Soil	Volume (m3)	Cost (`)	Economy (%)
Blank			
• Unsoaked	1960	2,94,000/-	
• Soaked	2590	3,88,500/-	
Soil + 5% Lime + 10% Flyash			
• Unsoaked	1890	2,83,500/-	3.57
• Soaked	2450	3,67,500/-	5.40
Soil + 5% Lime + 20% Flyash			
• Unsoaked	1610	2,41,500/-	17.85
• Soaked	2240	3,36,000/-	13.51
Soil + 5% Lime + 30% Flyash			
• Unsoaked	1260	1,89,000/-	35.71
• Soaked	1890	2,83,500/-	27.02



Alluvial Soil:-

Soil	Volume (m3)	Cost (`)	Economy (%)
Blank			
• Unsoaked	1470	2,20,500/-	
• Soaked	1820	2,73,000/-	
Soil + 5% Lime + 10% Flyash			
• Unsoaked	1260	1,89,000/-	14.28
• Soaked	1610	2,41,500/-	11.53
Soil + 5% Lime + 20% Flyash			
• Unsoaked	1120	1,68,000/-	23.80
• Soaked	1470	2,20,500/-	19.23
Soil + 5% Lime + 30% Flyash			
• Unsoaked	910	1,36,500/-	38.09
• Soaked	1120	1,68,000/-	38.46



Suggestions / Recommendations

1. Based on the above conclusions it can be suggested that the natural soil of Pune should be stabilized with Flyash & Lime on the commercial basis.
2. The lime & flyash together act as a better stabilizing material.
3. Since the more percentage reduction in pavement thickness has been achieved, by mixing Flyash & Lime but use of it in highways and rural roads will certainly yield in terms of economy because a large amount of flyash can be shifted from thermal power plants and a great problem of its disposal as well as environmental pollution would be solved.
4. The sites used for dumping flyash can be used for better purposes.

Scope of Future Investigation

Effects of Flyash to contamination of underground water.

- Natural soil has been stabilized with flyash and lime.
- Percentage of mixing these stabilizing materials should be extended to get the optimum minimum thickness of pavement for economical design of pavement.

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