DESIGN OF SOIL CEMENT ROAD

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Abstract – *Soil – cement is the simple product of Portland cement blended with soil and or aggregate, and water and compacted for use in pavement structure. It is an engineered material designed and constructed for various pavement applications or material characteristics. The present project is a practical study on using Soil cement product as the pavement material. As a part of this project various laboratory test like CBR test, standard proctor's test were conducted and also traffic volume studies are done. Finally the results shown that the soil is suitable for using sub base course of flexible pavement.*

Key Words: **Soil – cement, pavement, design, sub base, flexible pavement.**

1. INTRODUCTION

Transportation is the backbone to the development of urban areas. With growth, the mobility needs increases. People's use of personalized vehicles increases. This resulting in traffic congestion and delay to overall mobility of the people in urban areas. Increased costs associated with the use of high quality materials have led to the need for local soils to be used in geotechnical and road construction. The addition of a few percentages by weight of Portland cement has shown its effectiveness towards better control of workability during compaction. On this context we introduce our project. It is a practical study on using soil cement product as the pavement material.

2. OBJECTIVES

The main objective of the project is in order to introduce the road pavement construction using soil cement. Soil cement roads are one of the best options for the improvement of road densities in developing countries like India. Soil cement is frequently used in road construction as a sub base layer reinforcing and protecting the sub grade. It has good compressive and shear strength. It is an inexpensive pavement material with long life and high strength.

The following broad objectives have been identified for the study:

- To conduct the existing traffic conditions of the Pala town.
- To conduct reconnaissance survey along the proposed alignment.
- To conduct topographic survey using Total Station.
- Geotechnical survey and traffic survey.
- Preparation of alignment design drawings.
- Design of pavement.
- Preparation of detailed cost estimate.

3. CRITICAL REVIEW

3.1 GENERAL

Engineers are often faced with the problem of constructing roadbeds on or with soils, which do not possess sufficient strength to support wheel loads imposed upon them either in construction or during the service life of the pavement. It is, at times, necessary to treat these soils to provide a stable sub grade or a working platform for the construction of the pavement. These treatments result in less time and energy required for the production, handling, and placement of road and bridge fills and sub grades and therefore, less time to complete the construction process thus reducing the disruption and delays to traffic. These treatments are generally classified into two processes, soil modification or soil stabilization. The purpose of sub grade modification is to create a working platform for construction equipment. The concrete pavement using soil cement perform well under poor drainage conditions and thus avoid wastage of resources on repeated treatment of flexible pavement. The pavement design using soil cement is observed to be cost effective.

3.2 EARLIER RESEARCHES

[1] Ravi Kumar T, Sai Krishna K, Syamprasad S, Ramesh B, Parvathi G, Vinod T, Nagaraju P (2017)

This paper presents that Soil cement roads are better and economical way to provide rural road facility where the traffic volume is very low. Soil-cement is the simple product of Portland cement blended with soil and or aggregate, and water and compacted for use in pavement structure. It is an engineered material designed and constructed for various pavement applications or material characteristics. This paper presents a practical study on using soil cement product as the pavement material. The results of this paper shown that the soil is suitable for using base course and sub base course of flexible pavement in the conditions of low volume traffic flows.

[2] John E. Michener (2008).

The premise of this research is that the allowable delay time between mixing of a soil-cement mixture and completion of compaction may be shorter or longer than the widely adopted industry standard of 2 hours, depending upon environmental factors. Accordingly, the specific objectives of this research were to quantify the effects of certain environmental factors on the relative strength loss of soil-cement subjected to compaction delay and to develop a numerical tool that can be easily used in the field by engineers and contractors for determining an acceptable compaction delay time for individual projects based on environmental conditions at the respective sites. Knowing in advance how much time is available for working the soil-cement will help contractors schedule their activities more appropriately and ultimately produce higher quality roads. Specific factors selected for investigation in this research included material type, cement content, wind speed, temperature, relative humidity, and compaction delay.

[3] Arumugam and K. Muralidharan (1997)

It was about stabilizing the locally available soils and using them as subgrade materials generally reduce the cost of pavement construction. It was concluded that the mechanical stabilization saving in the construction cost of pavement up to 43% has been effected. Lime and cement stabilization saves the amount by 46.2% and 27.56% respectively.

[4] Abu Siddique and Bipradas Rajbongshi (2002)

A study of Mechanical properties of a cement stabilized coastal soil for use in road construction, this paper present the soil cement stabilization with 1%, 3%, and 5% cement fulfill the requirements of road sub-base and base subjected to light traffic. Analyses using CIRCLY computer program were conducted to estimate the thickness of soil-cement for paved and unpaved rural road maximum width 2.5 m and subjected to anticipated design traffic loading of light cross country vehicle (LCCV), i.e., and jeep.

[5] Manikant Mandal and Dr, Mayajit Mazumdar (1995)

This study was made on the effect of additives on lateritic soil stabilization with cement and lime. Particularly, the strength and fatigue behavior, under repeated flexure, of stabilized lateritic soil treated with additives, have not been studied in our country till now.

[6] Reddy and Gupta (2007)

They conducted research on soil cement block masonry.
Their paper focused on an experimental study in understanding the various characteristics of cement soil mortars in the fresh and hardened state. Workability, strength, water retentivity, shrinkage and stress-strain characteristics of cement soil mortars and bond strength of soil-cement block couplets using such mortars were examined. From the results obtained, they concluded that the composite mortars like cement-soil and cement-lime mortar can attain higher flow values without segregation of constituent materials. Cement-soil mortar possesses better water retentivity when compared to cement mortar and cement-lime mortar. The drying shrinkage value for cement-soil mortar is very high as compared to cement mortar. Cement-soil mortar gives higher bond strength with the decrease in clay percent. In soil cement mortar, flow value is controlled by clay fraction of the mortar mix rather than cement content of soil mortar. Whereas in the case of cement mortar and cement-lime mortar, cement content of the mix controls the flow value. Cement-soil mortar leads to better tensile bond strength when compared to cement mortar and cement-lime mortar.

[7] Costas A.Anagno– stopoulos (2004)

In this study, a laboratory test programme was carried out to find out the effect of inclusion of cement and acrylic resin on physical and engineering behaviour of a soft clay. A series of tests are conducted with the addition of 5% to 30% of cement contents and acrylic resin of 5%. It is concluded that the development of strength and stiffness for a short curing time (7 days) is delayed significantly because of A.R addition while for long curing time (28 days) the engineering parameters are increased considerably.

[8] T.Lopez-Lara, J.A. Zepeda- Garrido and V.M. Castario (1999)

This paper includes the evaluation of the main index properties of the soil, along with a characterization of the materials through X-ray diffraction.

3.3 SUMMARY OF LITERATURE REVIEW

All the literatures deals with the use of stabilization to improve the properties of a material is becoming more widespread due to the increased strength and load spreading ability that these materials can offer. A collective experience has demonstrated that cement can be mixed to increase the strength of soil in different ways. However, the basics always remain the same: treated soil is the simple product of cement with soil. There is no secret ingredient or proprietary formula that makes treated soil mixed with cement. Stabilization is the process of mixing a stabilizer, for example cement, with a soil or imported aggregate to produce a material whose strength is greater than that of the original unbound material. In this report soil has been taken from PALA, and several laboratory test is done on that soil sample and soil mixed with cement. The experiments done on the treated and untreated soil are Atterberg‟s limit (liquid limit and plastic limit), Standard proctor test, Direct shear test and California bearing ratio (CBR) test by adding 3%, 5%, and 7% cement on the soil sample.

4. MATERIALS USED

SOIL CEMENT:

A cement-modified soil contains relatively small proportions of Portland cement. The result is caked lightly harden material, similar to a soil, but with improved mechanical properties –lower plasticity, increased bearing ratio and shearing strength, and decreased volume change.

Also it have various properties like:

- Stiffness
- Great strength
- Superior performance
- Economical
- Low initial cost
- Fast construction
- Recycling of existing materials

5. RESULTS AND DICUSSION

5.1 TRAFFIC SURVEY

Traffic volume is the number of vehicles crossing a section of road per unit time at any selected period. Manual count method is adopted. Traffic volume counts were carried out at various homogeneous sections of the route.

5.1.1 ADOPTED PASSENGER CAR UNITS (PCU) VALUES

PCU is a measure of relative space requirements of a vehicle class compared to that of a passenger car under a specified set of roadway, traffic and other conditions.

Table.5.1 PCU Factor

SL. NO.	VEHICLE TYPE	PCU FACTOR
1	Car	1.0
2	Mini bus, Light truck	1.5
3	Standard bus, Medium truck	3.0
4	Two wheelers, Cycle	0.5
5	Auto Rickshaw	1.0
6	Agriculture Tractor	4.0
7	Cycle Rickshaw	2.0

5.1.2 TRAFFIC VOLUME DATA

The data collected from PALA junction was tabulated and analysed for:

- Traffic volume data.
- Volume – time graph from the tabulated.

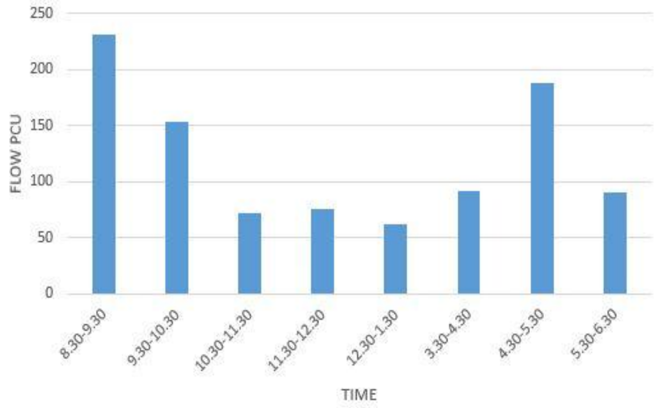

Chart – 1: Traffic volume Data on Pala - Vaikom road

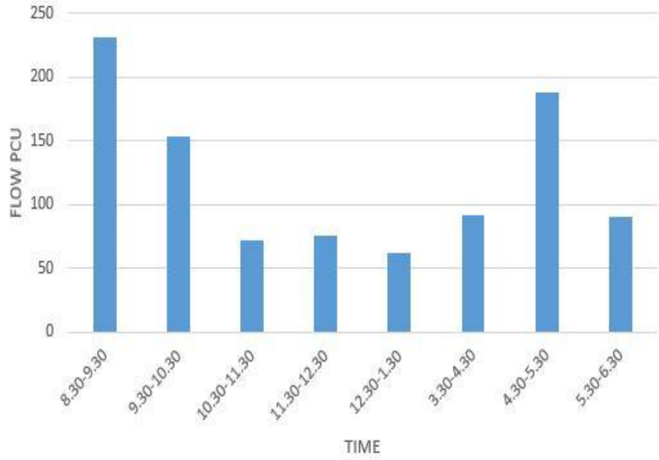

Chart – 2: Traffic volume Data on Pala – Thodupuzha parallel road.

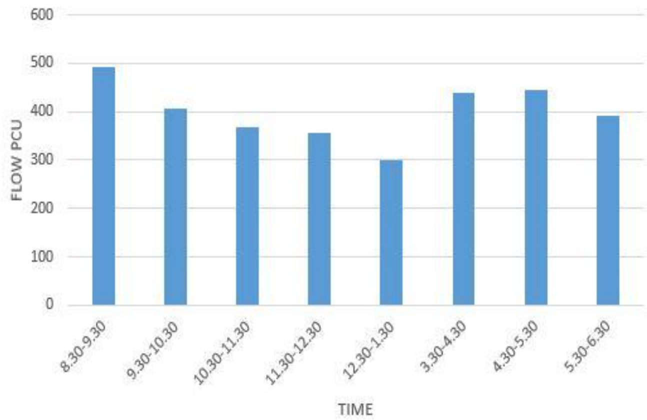

Chart – 3: Traffic volume Data on Kottayam – Thodupuzha parallel road.

5.2 CALIFORNIA BEARING RATIO TEST

California Bearing Ratio test is conducted in laboratory. This tests provides the load penetration resistance of soil. CBR value is obtained by measuring the relationship between force and penetration when a cylindrical plunger is made to penetrate the soil at a standard rate. The CBR test is used for the evaluation of subgrade strength of roads and pavements. The CBR value obtained by this test is used with the empirical curves to determine the thickness of pavement and its component layers. This is the most widely used method for the design of flexible pavement. Even though provision of subsoil drains reduces the effect of water on subgrade, fully soaked CBR tests shall be considered to be appropriate for road construction projects.

Table.5.2 Test result of soil with cement

MIX DETAILS	PERCENTAGE
SOIL+3% CEMENT	97.3%
SOIL+5%CEMENT	125.41%
SOIL+7%CEMENT	94.09%

From this it's concluded that CBR value maximum obtained at soil + 5% cement is 125.41%, which having a good subgrade strength. So 5% cement with soil is adopted for the stabilization of sub base layer.

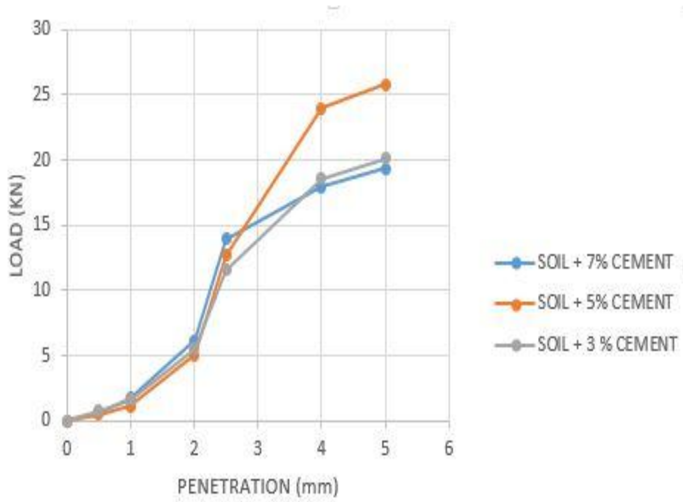

Chart -4: CBR

5.3 TEST ON SOIL

Table.5.3 test results on soil

SL.NO	TEST	RESULTS
1	GRAIN SIZE ANALYSIS	UNIFORMITY COEFFICIENT=3.03 COEFFICIENT OF GRADATION=0.98
2	CONSISTENCY LIMIT	LIQUID LIMIT=19.68% PLASTIC LIMIT=14.6%
3	STANDARD PROCTOR'S TEST	OPTIMUM MOISTURE CONTENT=17.5% MAXIMUM DRY DENSITY=1.7g/cc
4	CBR	15%

5.4 PROCTOR'S TEST

This soil compaction test also called as Proctor test is used for the determination of the mass of dry soil per cubic meter when the soil is compacted over a range of moisture contents, giving the maximum dry density at optimum moisture content. Thus this test provides the compaction characteristics of different soils with change in moisture content. This is achieved by densification of soil by reducing the air voids. The degree of is measured in terms of its dry density of soil. The dry density is maximum at the optimum water content.

Table 5.4 Standard proctors' values

SI. NO	DETAILS OF MIX	OPTIMUM MOISTURE CONTENT (%)	MAXIMUM DRY DENSITY(g/cc)
1	SOIL+3%CEMENT	6.of 85	1.89
2	SOIL+5%CEMENT	9.90	1.99
3	SOIL+7%CEMENT	8.45	1.91

From this it can be inferred that soil +5% attain maximum values.

6. PAVEMENT DESIGN

Pavement structural design is a crucial aspect and should be an integral part of all the stages of a project .Guidelines for design of flexible pavements are IRC: 37 - 2012 and AASHTO guidelines.

$$N = \frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F$$

- N= the cumulative number of standard axles to be catered for in the design in terms of msa
- A= the initial traffic in the year of completion of construction in terms of number of commercial vehicles per day
- D= lane distribution factor
- F= vehicle damage factor
- n= design life in years
- r= annual growth rate of commercial vehicles

6.1 COMPUTATION OF DESIGN TRAFFIC

DATA:

- Initial traffic, A= 377.88 CV/day
- Design CBR of subgrade soil= 15%
- Design life, n = 20 years
- Vehicle damage factor, F= 3.5 (standard axles perCV)
- TRAFFIC growth rate per annum, r = 7.5%

DESIGN CALCULATIONS:

- Distribution factor= 0.5 (as per IRC 37- 2001, clause 3.3.5 for two lane carriage way)

$$N = \frac{365 \times [(1+r)^n - 1]}{r} \times A \times D \times F$$

- $A = P^*(1+r)^x$
- $N = \frac{365 \times [(1+0.075)^{20} - 1]}{0.075} \times 377.8 \times 0.5 \times 3.5$

  = 10 msa

- **For Granular Base and Granular Sub base.**
- Use IRC 37:2012 Total pavement thickness for CBR 15% and traffic 10 msa from IRC:37 2012 plate 8 = 530 mm
- Pavement composition can be obtained by interpolation from Pavement Design Catalogue (IRC: 37 2012).

(a)Bituminous surfacing = 40 mm SDBC + 40 mm DBM
(b) Road-base = 250 mm WBM
(c) Sub-base = 200 mm granular material of CBR not less than 15 %

- **For Soil – Cement road pavement.**
- k value = 200
- Fatigue Factor = 12

(a)Sub base thickness = 5.1 in.
= 5.1*25.4
= 129.54 mm
=130 mm
(b) Bituminous surfacing = 40 mm SDBC + 40 mm DBM
(c) Road-base = 250 mm WBM
(d) Overall thickness = 460 mm

7. CONCLUSION

The design is done as per the recommendation of the IRC 37:2012 and guidelines of AASHTO pavement design. The CBR value obtained for subgrade soil is 15 %, which is having a good subgrade strength. Maximum CBR value is obtained when soil is mixed with 5 % cement. And the obtained CBR value is 125.41 %. The overall thickness obtained for the ordinary road pavement is 530 mm and for soil cement road it is 460 mm. Thus there is a reduction of 70 mm is achieved, which makes the road construction of road pavement using Soil Cement is more economical. Thus it can be As compared to the flexible pavement cost, the soil cement have low initial cost of construction.

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