STABILISATION OF SUBGRADE SOIL USING DEMOLISHED CONCRETE AGGREGATE

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Abstract:- *Long term performance of pavement structures depends on the stability of subgrade soil. Stabilisation of subgrade soil improves its properties and strength. Red soil is the third largest soil group in India. Red soils possess lower strength compared to other soil due to its porous and fragile structure and it has a higher swelling capacity, thereby it requires stabilisation. Red soil stabilisation is usually done using lime, fly ash, granulated blast slag etc., of which construction & demolition waste is major factor. This project aims to study the engineering properties of red soil & to determine the stability of subgrade soil after using the construction waste as the stabilising agent. The debris is added in varying percentage to the soil & the strength is calculated. The variation in strength of subgrade may result in the reduction of pavement thickness.*

Key Words: **Red soil, Subgrade, Stabilisation, Demolished concrete aggregates, CBR, Proctor**

1. INTRODUCTION

Red soil is a type of soil that develops in a warm, temperate, moist climate under deciduous or mixed forest, having thin organic and organic-mineral layers overlying a yellowish-brown leached layer resting on an alluvial red layer. Red soils are generally derived from crystalline rock. They are usually poor growing soils, low in nutrients and humus and difficult to cultivate because of its low water holding capacity. Red soils denote the third largest soil group of India covering an area of about 3.5 lakhs sq. km (10.6% of India's area). It is a weak foundation material and has caused a number of failures to structures and embankments built over it. Since the soil is very weak, the subgrade often fails and thus it leads to the pathetic condition of the roads in southern parts of Thiruvananthapuram in Kerala, causing a huge amount of money in repairs. Over the years various methods have been employed to stabilize the soil throughout history.

Road & roadside stabilisation is important in maintaining our landscapes integrity by stopping the leaching of water based & airborne pollution, preventing hard panning & increased salt content of soils protect native land & increase the strength of roads & embankments. Soil stabilisation is the alteration of soils to enhance their physical properties. Stabilisation can increase the shear strength of a soil and control the shrink-swell properties of a soil, thus improving the load bearing capacity of a sub-grade to support pavements and foundations. Some of the traditional methods include addition of lime, cement, mortar etc. Though these methods may prove effective they are not always budget friendly and also may sometimes cause harm to the environment. Thus, it is very important to find methods of soil stabilisation that will prove both cost effective and also help secure the environment.

2. METHODOLOGY

Various experiments are conducted to determine the properties of red soil and demolished concrete aggregate. Various properties of soil such as liquid limit, plastic limit, shrinkage limit, plasticity index, etc. are determined. Modified proctor tests are conducted to determine the maximum dry density and optimum moisture content of the soil. California bearing ratio testis also conducted to evaluate the stability of the soil. Demolished concrete aggregates are also tested as per IS 2386:1963 to determine specific gravity, water absorption, impact value, crushing value, abrasion value, etc. Stabilisation of red soil is done by performing a series of modified proctor tests with the addition of different proportions of demolished concrete aggregates. The optimum amount of aggregates required to stabilise the soil is determined. California bearing ratio tests are also conducted on soil with different proportions of demolished aggregates. Traffic volume is studied to determine the number of vehicles crossing a section of a road per unit time at selected period. For pavement design, apart from the general soil tests, CBR test should be carried out depending on the requirements in IRC 37:1970 and IRC 37:2012. Pavement thickness is determined by various methods such as California bearing ratio method using IRC charts, Cumulative axle load method.

3. RESULTS

3.1 Red Soil

The subgrade soil used in the study is red soil, which was collected from Killipalam of Trivandrum district. The properties of the subgrade material were found out as per IS and the results obtained are tabulated in Table 3.1. It has an unsoaked CBR value of 2.3% and hence could be classified as poor subgrade. Therefore, there is a need to stabilize this soil so that it qualifies as a strong subgrade.

Table 3.1 Properties of Red Soil

Properties	Value
Natural Moisture Content	4.07%
Specific Gravity	2.17
Liquid limit	38%
Plastic limit	28.8%
Shrinkage limit	25.29%
Plasticity index	9.2
Percentage of gravel	3.2%
Percentage of sand	76%
Percentage of silt	20.8%
Maximum dry density	1.7g/cc
Optimum moisture content	18.8%
CBR(unsoaked)	2.37%

3.2 Demolished Concrete Aggregates Construction and demolition concrete aggregates were collected from various construction and demolition sites in and around Thiruvananthapuram district, Kerala. The collected waste materials were then crushed to smaller sizes manually. Size of the aggregate used varied upto 20mm. The properties of demolition concrete wastes used are tabulated in Table 3.2. It showed that the aggregates were of sufficiently good quality.

Table 3.2 Properties of demolished concrete aggregates

Property	Value
Specific gravity	2.52
Aggregate impact value(%)	26.47
Aggregate crushing value(%)	38.40
Aggregate abrasion value(%)	32.60
Angularity	6.00
Water absorption(%)	2.39

3.3 Effect of Red Soil Mixed With Demolished Aggregate

A series of Standard Proctor tests were performed in the laboratory with the addition of different proportions of crushed demolition concrete aggregates varying from 0% to 60% with an increment of 10%. Their compaction curves are shown in Figure 3.1. Based on the Standard Proctor test results, it was observed that, for soil sample mixed with different proportions of crushed demolition concrete waste aggregates, the density increased first and then decreased with the addition of crushed demolition waste aggregates. By the addition of 40% of crushed demolition concrete waste aggregates, the maximum dry density (MDD) of the soil sample was increased from 1.70g/cc to 1.95g/cc. It can be understood that an increase of dry density means a decrease of voids ratio and a more compact soil. This variation in maximum dry density could be because of the variation in void ratio when demolition concrete aggregate waste was added. Further addition of waste resulted in a decrease in value of the maximum dry density. The OMC tend to decrease as the percentage of concrete waste increased. However the optimum Moisture Content goes on decreasing first and then increases.

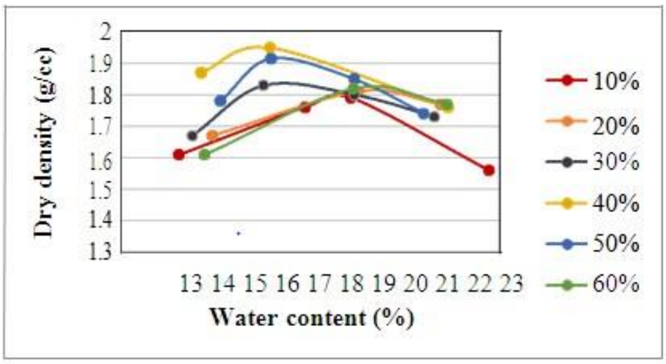

Chart – 1 : Compaction Curves of red soil mixed with demolished aggregate

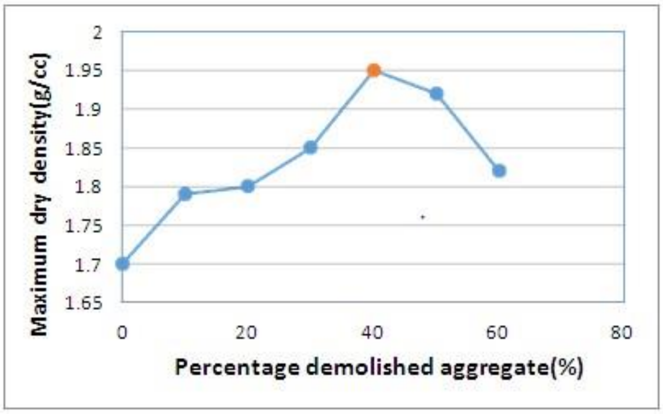

Chart –2: MDD Vs. percentage demolished aggregate

3.4 Effect of Demolished Concrete Aggregate on CBR of Soil

A series of unsoaked CBR tests were performed in the laboratory with different proportions of demolished concrete aggregates varying from 0% to 60% with an increment of 10% at their respective maximum dry density and OMC. The variation of CBR values (unsoaked) of red soil with varying percentages of demolished concrete aggregate is shown in Table 3.3. Based on the CBR test results, it was observed that the CBR value first increased gradually and then decreased with the addition of demolished concrete aggregates added. However the CBR value increases due to the increase in load-bearing capacity of soils when demolished aggregate was added to the soil. With addition of 40% of demolished concrete aggregate CBR value was increased from 2.37% to 24.09%.

Table 3.3 CBR value of soil with demolished aggregate

Amount of demolished aggregates added(%)	CBR Value(%)
0	2.37
10	9.87
20	15.24
30	21.60
40	24.09
50	22.53
60	19.86

3.5 Pavement Design

The traffic survey was conducted on three days at Killipalam, Thiruvananthapuram. The survey was conducted for 6 hours in two sessions covering morning and evening peak hours. Morning session was between 8am to 11am and evening session was between 3.30pm to 6.30 pm. Hourly volume count were taken and accumulated directionally. The manual method of traffic count was adopted for calculating traffic volume. The study details were tabulated and vehicle classification systems adopted for the study are two-wheelers, three-wheelers, buses, passenger car, auto-rickshaw and truck. The average present day traffic is determined to be 1940 cv/day. The pavement thickness was determined using two methods considering 40% as optimum amount of demolished concrete aggregates. ***California Bearing Ratio Method***

According to the guidelines of IRC 37:2012. For the design, some reasonable assumptions had to be made, traffic growth rate factor 7.5% and design life of 10 years. For this method the total pavement thickness required is 20 cm according to IRC charts.

CBR Method of Pavement Design by Cumulative Standard Axle Load

According to the guidelines of IRC 37:2001, the various assumptions made are traffic growth rate factor 7.5%, vehicle damage factor (VDF) 2.5, lane distribution factor 0.75, and the design life as 10 years. Based on this, a cumulative standard axle value of 7.71 msa was arrived at. . For this method the total pavement thickness required is 25 cm according to IRC charts.

Pavement Section

According to IRC specifications, a minimum thickness of 30cm is provided for the stability of pavement. Since the CBR value is much higher than the required minimum value, a combined base and sub base layer of thickness 25cm is provided. Provide well graded gravel of CBR value of 90% or demolished concrete aggregate of CBR value 95% in this layer. Also provide bituminous concrete surface course of thickness of 5 cm and a semi dense bituminous concrete wearing course of thickness 2.5cm.

4. CONCLUSIONS

From the experimental study the following conclusions were made:

- The addition of demolished aggregate to the red soil leads to the reduction of optimum moisture content and increase of maximum dry density.
- The optimum amount of aggregate was found to be 40%.
- The OMC was decreased from 18.8% to 17.5% and maximum dry density increased from 1.7g/cc to 1.95g/cc with 40% addition of aggregates.
- The CBR value of the unsoaked soil was raised from 2.37% to 24.09%.
- The thickness of pavement is reduced from 70cm to 30cm. Hence; cost of construction of pavement can be reduced.

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