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A Study on Use of Red Mud as Sub-Grade in Road Construction

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Abstract: **Red mud is the industrial waste produced during the extraction of aluminium from bauxite. Globally, nearly 75 million tons of red mud is produced annually. The red mud is highly basic in nature with pH ranging from 10-13 and storage of such a large quantity of red mud needs large area of useful land. Also, occasional failure of red mud tailing dam causes causalities, flooding of the land and mainly it pollutes the surface water due to its high alkalinity. Hence to minimize the storage of red mud, it is required to utilize this waste as alternate engineering material. The main aim of this paper is to investigate the use of red mud in road construction as sub grade. All other necessary properties of the soil sample have been determined in the laboratory such as consistency limits, specific gravity, grain size distribution compaction characteristics and CBR value in accordance with Bureau of Indian standards (BIS) specifications. CBR value is one of the important parameters which indicates the strength of soil sub base of road pavement.**
The test results indicated that the red mud as sub grade in pavement design met the specification of BIS.

Keywords: Red Mud, CBR, Pavement Subgrade Material.

1. INTRODUCTION

Red mud, also known as bauxite residue, is an industrial waste generated during the refinement of bauxite into alumina using the Bayer process. It is composed of various oxide compounds, including the iron oxides which give its red colour. Over 95% of the alumina produced globally is through the Bayer process; for every tonne of alumina produced, approximately 1 to 1.5 tonnes of red mud are also produced.

Due to this high level of production and the material's high alkalinity, it can pose a significant environmental hazard and storage problem. As a result, significant effort is being invested in finding better methods for dealing with it.

Red mud is composed of a mixture of solid and metallic oxides. The red colour arises from iron oxides, which comprise up to 60% of the mass. The mud is highly basic with a pH ranging from 10 to 13. In addition to iron, the other dominant components include silica, unleashed residual alumina, and titanium oxide.

2. OBJECTIVE

The main objective of this paper is to investigate the use of red mud in road construction as sub grade. All other necessary properties of the soil sample have been determined in the laboratory such as consistency limits, specific gravity, grain size distribution compaction characteristics and CBR value in accordance with Bureau of Indian standards (BIS) specifications. CBR value is one of the important parameters which indicates the strength of soil sub base of road pavement.

The test results indicated that the red mud as sub grade in pavement design met the specification of BIS.

3. LITERATURE REVIEW

1. *J.S. Nogami and D.F. Villibor*,

This paper represents successful uses of laterite fine grained soil in pavement base course in large area of Brazil and other tropical countries. It is found that the laterite fine grained soil, even though they do not conform to the requirements of most traditional specifications for base course, are being used satisfactorily in medium to light traffic road, small airport, streets and parking lots.

2. Y. Dingrara, et. al.

Laterite soil of Papua region of Indonesia was treated with lime and cement and laboratory and field-testing programs were conducted for application in the evaluation procedures of pavement structures. In this study, it was found that the optimum value of strength was achieved at PCC 5% with lime content 12% where the compaction rate and field CBR value of the treated soil were 86.2% and 112.44% respectively.

4. MATERIAL AND METHODOLOGY

- A soil sample of red mud is collected from the Chittorgarh region of Rajasthan and various important test are carried out in civil engineering laboratory such as
- Particle size distribution – to find the grade of Red Mud
- Liquid limit test – to determine liquid limit of Red Mud using Casagrande apparatus
- Plastic limit test – to determine plastic limit of Red Mud using Casagrande apparatus
- Core cutter test – to determine optimum moisture content and maximum dry density of Red Mud
- Specific Gravity test – to find specific Gravity of Red Mud
- California bearing ration ratio test – to find CBR value

5. RESULTS

Grain Size distribution

The composition of soil particles is of a variety of sizes and shapes. The range of particle size present in the same soil sample is from a few microns to a few centimetres. Many physical properties of the soil such as its strength,

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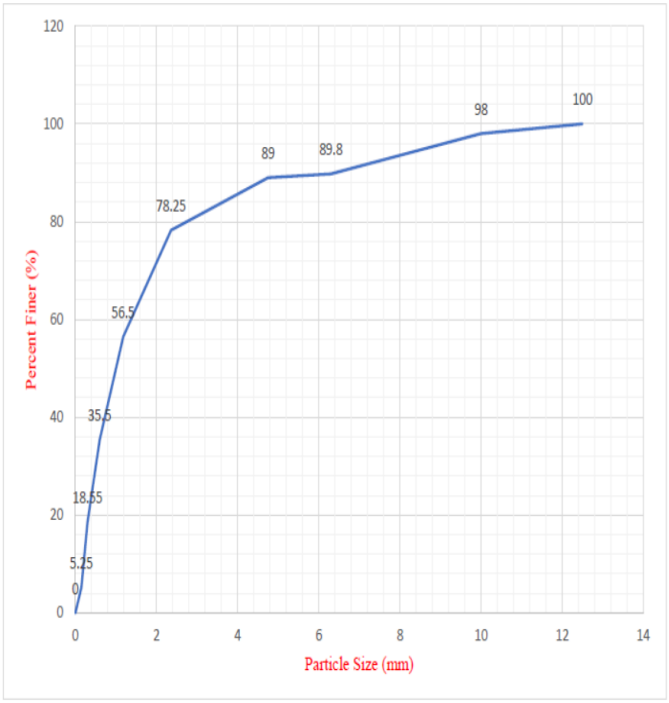
permeability, density etc are depended on different size and shape of particles present in the soil sample. Soil grain property depends to individual solid grain and remains unaffected by the state in which a particular soil exists in nature. Well graded or poorly graded are mainly the types of soil found. Well graded soils have different particles of different size and shape in a good amount. On the other hand, if soil has particles of some sizes in excess and deficiency of particles of other sizes then it is said to be poorly or uniformly graded.

Here 2000 gm of sample soil was taken and dried in oven for 12 hours. Mostly used test for grain size distribution analysis is sieve analysis. Ten sieves were used. And the results from sieve analysis of the soil are plotted on a semi-log graph with particle diameter or the sieve size in X axis and percentage finer in Y axis.

Table 1: Grain Size Distribution Result

Sieve No. #	Sieve Size	Mass of soil retained in each sieve(gm)	Percent Retained (%)	Cumulative Retained (%)	Percent Finer (%)
1/2 Inch	12.5 mm	0	--	0	100
3/8 Inch	10 mm	40	2	2	98
1/4 Inch	6.3mm	164	8.2	10.2	89.8
#4	4.75mm	16	0.8	11	89
#8	2.36mm	215	10.75	21.75	78.25
#16	1.18mm	435	21.75	43.5	56.50
#30	600 micron	420	21	64.5	35.50
#50	300 micron	339	16.95	81.45	18.55
#80	150 micron	266	13.3	94.75	5.25
PAN	--------	105	5.25	100	0



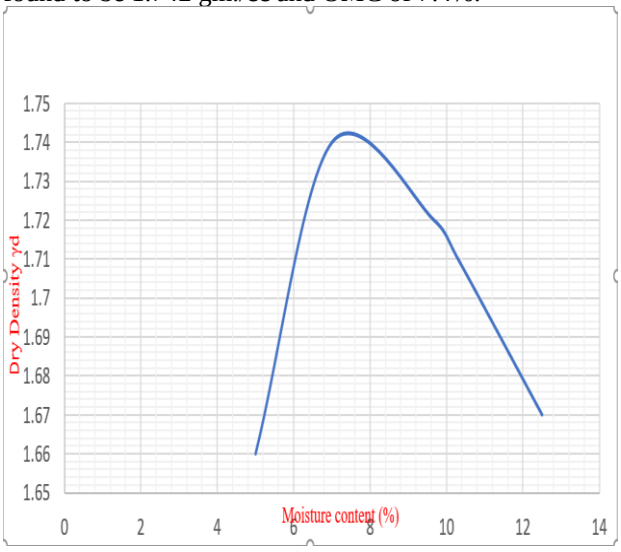
Graph 1: Grain size distribution graph

Liquid limit and Plastic limit Test Results

With the help of Casagrande apparatus we get the following results.
Liquid Limit (WL) = 25.50%
Plastic Limit (WP) = 18.26%
Plasticity Index (IP) = 7.24%

Compaction Test

Very commonly used modified proctor test has been executed for 2500 gm soil sample taken for each trial. Modified proctor test was followed according to IS standard. From this test, maximum dry density of the specimen was found to be 1.742 gm./cc and OMC of 7.4%.



Graph 2: Modified proctor test graph

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Specific Gravity Test

Table 2: Specific Gravity Test Result

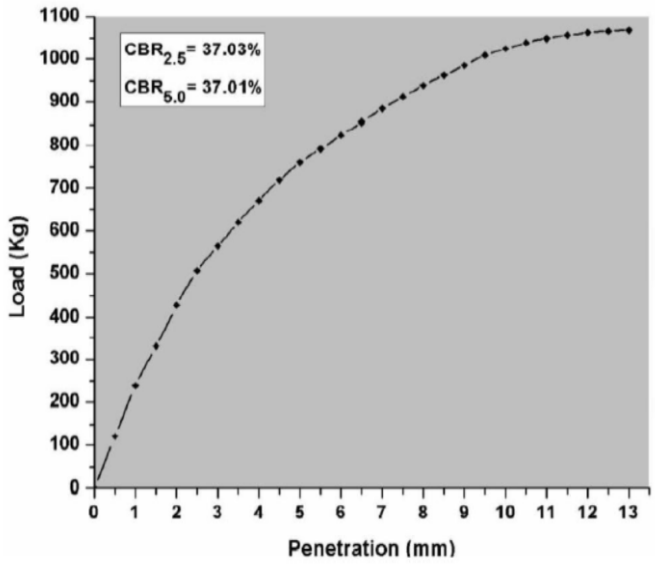
Sample No.	M1(gm)	M2(gm)	M3(gm)	M4(gm)	Sp. Gravity
1	650	850	1570	1438	2.94
2	650	851	1572	1439	2.95
3	651	849	1571	1440	2.95

Here soil material is tested three times. And the average specific gravity value comes 2.726. But here no temperature correction is done. This test has been done in room temperature nearly 25*C.

CBR Test Results

Penetration in mm are plotted in X axis and load expressed in kg with corresponding points are plotted in Y axis and prepare graph for different specimen. The CBR values at 2.5mm and 5.0mm penetrations are calculated for each specimen from the corresponding graphs which is shown below. Generally, the CBR value at 2.5mm penetration is higher and this value is adopted. CBR is defined as the ratio of the test load to the standard load, expressed as percentage for a given penetration of the plunger. This value is expressed in percentage. Standard load of different penetration is discussed before.

Since as per IRC 37 – 2012, sub-grade soil should have a minimum CBR of 8% for roads having traffic of 450 commercial vehicles per day or higher, hence selected soil sample meet the required specification.



Graph 3: CBR Test Result

6. CONCLUSION

The main objective of this paper is to make the use of red mud in road construction as subgrade. Red mud is widely available in Chittorgarh. IRC 37 – 2012 provides guidelines for design of flexible pavements. As per the guidelines, the soil forming the subgrade should have a minimum CBR of 8% for roads having traffic of 450 commercial vehicles per day or higher. From the California bearing ration test of the soil sample is 37.03%, which meet the required specification. So, it can be concluded that red mud can be used in road construction as subgrade.

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