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Geotechnical Characteristics Of Red Mud As A Subgrade Material Stablized by RHA AND Ground Grainated Blast Furnace Slag

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Abstract - *A huge amount of wastes and other by-products are produced annually by industrial, commercial and other human activities. The generation of this huge amount of wastes pose different problems related to their safe disposal and management. Rapid development and shortage of natural and conventional materials compel us to utilise the industrial wastes as their replacement in different engineering works. This approach of utilising wastes as alternate materials also leads to sustainable development.*

Red mud, rice husk ash and ground granulated blast furnace slag are the industrial wastes which are having a reasonable potential in construction works when utilised properly. Red mud is generated as a by-product during refining of alumina from bauxite ore. The approximate annual global production of red mud is 75 mt out of which India produces around 9-10 mt accounting nearly 5% of the total production. There exists a global stock of more than 3 billion mt of red mud. The aim of current study is to view the suitability of red mud as a subgrade construction material by stabilising it with RHA and GGBS. RHA and GGBS acts as a pozzolanic material and enhance the properties of RM making it advantageous and a suitable material.

Key Words: Rice husk , Alminia ,Red mud ,slag etc

1. INTRODUCTION

This In the recent past industrial sector, mainly the processing and manufacturing industries faced the major challenges regarding the disposal of different waste materials produced. The main contributers towards the production of toxic wastes is the extractive metallurgy including ore-dressing and mineral processing. In the recent past industrial sector, mainly the processing and manufacturing industries faced the major challenges regarding the disposal of different waste materials produced. On the other hand, the rapid development demands more materials and other assets. In the recent past there has been a huge shortage of naturally available materials and other assets for the ongoing construction and development activities. The rapid depletion of naturally available materials and resources is a cause of concern. Shortage of these materials, regulations and restrictions on the use of some naturally available resources compel us to utilise the industrial wastes, which also leads to the sustainable development. The waste materials negatively affect the environment having consequences on natural assets and living creatures. In India a huge number of construction undertakings are going on demanding a large quantum of adequate materials. The use of waste materials in different construction activities results in minimising the use of natural resources, besides reducing the environmental nuisance. There has been an amplifying interest in researchers to investigate and study the engineering characteristics of these large scale wastes, so as to use them as alternate construction materials.

Aluminium is mainly produced from bauxite ore by Bayers process. Approximately 6-7 tons of ore is processed to produce about 2-2.5 tons of alumina. Most of the alumina present in ore is dissolved leaving behind an insoluble residue known as bayers residue or red mud. Disposal of these large scale residues is a challenging job for alumina refineries. Red mud mainly consists of iron oxide along with silica and other minor elements. The global production of red mud is about 75mt/annum out of which Indias contribution is approximately 9-10 mt/annum which accounts about 5% of the total global production.

1.1 LITERATURE AND REVIEW

- BeforeK SATESH BABU, N G REDDY ET AL (2018) investigated the compaction characteristics of red mud(RM) admixed with lime and GGBS (Ground Granulated Blast Furnace Slag). It was observed that RM shows a range of dry density values. This susceptibility decreases considerable when admixed with lime or GGBS. The lime content was increased from 1% to 15% while as GGBS was added incrementally from 10% to 40%. From the results it was found that 2% lime and 25% GGBS is sufficient and most favourable for persistant and reliable results. It was concluded that RM can be used as a potential construction material for subgrade or embankments.

- SREEKANTAN, P GEETHA ET AL (2018) concluded that the waste RM has potential to be used as a construction material like raising embankments etc. The embankments can itself act as disposal place for these suitable industrial wastes. But the wastes need to be stabilised before being dumped or used for these purpose. FA (Fly ash) was mixed with RM (Red mud) with varying percentage of 5% to 50%. Laboratory investigations were carried on the said mix by different test as STP, permeability test and triaxial test. It was concluded that FA stabilised RM is suitable as an embankment material.

- MEHRAN NASIRI ET AL (2016) studied the utilization of RHA for stabilising sub-base material in construction and repair of roads. It was observed that addition of RHA increases OMC and decreases MDD. The LL(Liquid limit) % PI (Plasticity index) also decreases with RHA. The CBR & UCS increases by about 10% for optimum mix. It was concluded that 9%

- S K DAS, S K ROUT S ALAM (2015) studied the properties of red mud (RM) to check its viability as a subgrade material. The observations were made based on laboratory and finite element findings. Basic index and engineering properties were noticed and observed. It was observed that maximum dry density of red mud is comparably higher than other materials, mainly due to higher percentage of iron compounds in it. The maximum density of 16.7 KN/m3 was achieved at 20-22% of water.

- C H RAO, G NAIDU ET AL (2012) conducted a detailed laboratory investigation to determine the behaviour of GGBS stabilised RM. GGBS percentage was increased from 5% to 30% with an increment of 5% . UCS, CBR & Split tensile strength test were performed on the said mixes. The results were observed at curing of 1, 3 , 7 & 28 days. It was observed from test results that higher values were observed at 25% of GGBS and also at curing of 28 days higher values were obtained that other periods. Thus GGBS stabilised RM is a potential material and may be used as subgrade subbase or a base course material in the construction of roads.

1.2 METHODOLOGY AND MATERIAL USED

- SPECIFIC GRAVITY

The specific gravity of RM is determined according to the specifications of IS 2720 – Part III (section I) 1980. The specific gravity is obtained using density bottle.

- COMPACTION TEST

The moisture content and dry density relationship is determined using STP (Standard Proctor test) as per the specifications of IS 2720 – Part VII 1980. Red mud is mixed with different proportions of RHA ranging from 10% to 30% with increments of 5%. Reasonable amount of water is added to the mixture starting from 8% and the mixture is thoroughly blended and kept for saturation. The sample is then divided into three parts and compacted in the mould layer by layer. Each layer is compacted by 25 No. of blows using 2.6 kg hammer having free fall of 31 cm. The mould is waxed before placing the sample in it.

- UNCONFINED COMPRESSIVE STRENGTH TEST

UCS test is used to determine the strength of RM stabilised by RHA and GGBS and to get the optimum mix of the materials used. The UCS test is determined as per the specifications of IS 2720 – Part X 1991. The sample obtained for optimum values is used in UCS. The sample is kept for saturation for 24 hrs. the mould is waxed and sample is placed in the mould in three layers and rammed using standard rammer. the sample is then removed from the mould and setup in compression testing machine. The dimensions of the sample are same as that of the internal dimensions of mould 76mm in height and 36mm in dia.

RED MUD

The RM (Red mud) used in the present study was procured from NANGAL Enterprises Jammunanagar Gujarat. The sample obtained was available in 30kg packing and in fine powdered form.

Physical characteristics of RM sample

S.NO.	Property	Value
1	Colour	Red
2	Type	Fine grained
3	Bulk density(gm/cc)	1.31
4	PH	11.5

- RHA (Rice Husk Ash)

The RHA was procured from KN Enterprises Mandi Gobindgarh Punjab. The sample was dry, granular and black grey in colour.

Physical characteristics of RHA sample

S.No.	Property	Value
1	Colour	Black gray
2	Bulk Density (kg/m^3)	104
3	Fineness (cm^2/gm)	2775

2. 1 Results

Property	Site-1	Site-2
Specific gravity, *G*	2.65	2.7
% Finer than 75 µm	99	96
Gravel (%)	0	0
Sand (%)	1	4
Silt (%)	89	91
Clay (%)	10	5
Natural water content, *wn* (%)	28.2	34.4
Field dry unit weight, γ d (kN/m^3)	15.4	14.6
Liquid limit, LL (%)	37	45.8
Plastic limit, PL (%)	22.6	24.3
Plasticity index, PI = (LL-PL) (%)	14.4	21.5
Plasticity index, A-line, PIA = 0.73 (LL-20) (%)	12.4	18.8
Plasticity index, U-line, PIU = 0.9 (LL-8) (%)	26	34
Clay mineral	Illite	Illite
Classification	MI	MI
Consistency index, *IC*	0.6	0.5
In situ UCS, *q*u (kN/m^2)	57	48.6
In situ UCS, *c*u (kN/m^2)	27	24
In situ cohesion by direct shear test, *c*u (kN/m^2)	16.7	14
Angle of internal friction by direct shear test, Φu ($^\circ$)	31	26
Optimum moisture content (%)	19	22
Maximum dry unit weight (kN/m^3)	17	15.4

COMPACTION TEST RESULTS OF DIFFERENT MIX PROPORTIONS

The compaction test results of standard proctor test for different mix proportions are presented by plotting a graph between moisture content (%) and dry density (kg/cm^3).

S.NO.	% RHA	OMC (%)	MDD(kg/cm^3)
1.	10	24.45	1.67
2.	15	24.5	1.62
3.	20	24.54	1.58
4.	25	24.94	1.56
5.	30	25.34	1.53

From the above test results it is found that the maximum dry density goes on decreasing with increase in the percentage of RHA while as OMC increases and thus no productive results were obtained. It might be due to low specific gravity and high porous nature of RHA.

UNCONFINED STRENGTH TEST FOR DIFFERENT MIX PROPORTIONS

The results of UCS test are presented by plotting a graph between axial strain (%) and shear strength (kg/cm^2). The test results

S.NO.	%RHA	UCS(Kg/cm^2)
1.	10	2.53
2.	15	3.77
3.	20	3.19
4.	25	2.57
5.	30	1.94

The results obtained for different mix proportions conclude that UCS increases with increase in percentage of RHA and the maximum value of UCS is obtained at 15% of RHA and beyond this percentage the value of UCS starts receeding.

3. CONCLUSIONS

Civil engineers throughout the globe are doing various research works to get the alternative construction materials which would conserve natural scare resources and are cost effective for various activities such as road construction, fill material, embankment material, brics etc.

RM which is a waste product generated in huge quantity and posing various storage and disposal problems can be used as an effective construction material for subgrade, embankment, fills etc. The aim of current study is to view the suitability of Red mud as a subgrade construction material after stabilisation.

- The compaction test results does not give any productive result to determine the optimum mix of RM and RHA because MDD continuously goes on decreasing with increase in percentage of RHA and OMC goes on increasing with increase in percentage of RHA but addition of RHA increases UCS and CBR with a maximum value at 15%
- GGBS increases MDD of mix and increase occurs upto 20% of GGBS beyond which the value decreases. OMC also goes on increasing with increase in percentage of GGBS.

- UCS increases appreciably to 15.27 kg/cm^2 by addition of 20% GGBS and the further increase in percentage of GGBS decreases the strength.
- CBR value of RM is enhanced appreciable by RHA and GGBS making it a potential subgrade material.
- The maximum dry density values of final optimum mix comply to the minimum values required for the construction of subgrade and embankment.

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